COLLECTION AND ANALYSIS OF
REMOTELY SENSED DATA
FROM THE
RHODE RIVER ESTUARY WATERSHED

ANNUAL REPORT

October 10, 1971 to October 9, 1972

Prepared under Contract No. NAS6-1913 by

CHESAPEAKE BAY CENTER FOR ENVIRONMENTAL STUDIES

SMITHSONIAN   INSTITUTION

For

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

WALLOPS STATION

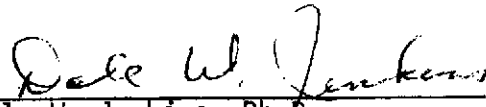**WALLOP ISLAND, VA. 23337**   October

COLLECTION AND ANALYSIS OF REMOTELY SENSED DATA

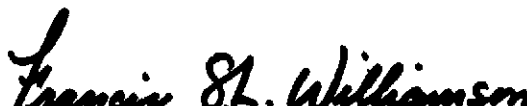FROM THE RHODE RIVER ESTUARY WATERSHED

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Contract No. NAS6-1913
National Aeronautics and Space Administration
Wallops Station, Wallops Island, Virginia 23337

Chesapeake Bay Center for Environmental Studies
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INTRODUCTION

The remote sensing study being conducted by the Smithsonian Institution and NASA,Wallops at the Smithsonian's Chesapeake Bay Center for Environmental Studies (the Center) underwent a major shift in emphasis during 1972, from the study of predominantly forest and field vegetation to that of salt marshes. The shift was made for three reasons: 1) in response to the greater emphasis placed by NASA on the problems of Chesapeake Bay; 2) to coincide with the need by the Chesapeake Research Consortium (CRC) for a wetland classification system; and 3) to promote the application of remote sensing by members of the Rhode River Program (RRP), a subgroup of the CRC working at the Center.

Before the marsh plants recommenced their annual growth in early summer, we concluded our work on the photointerpretation of forest and old field vegetation (begun in 1970-71). We sought a consistent basis for identifying species of forest trees by comparing natural color transparencies of their autumn foliage with standardized color chips from the Munsell Book of Color. Despite problems arising from small sample size and variations in illumination of the trees, the comparison with Munsell color chips proved to be a good identification technique for several species. This technique may also be feasible for separating and identifying species of salt marsh vegetation.

We also made a preliminary survey of the vegetation in an abandoned field and constructed a vegetation cover map. This survey anticipates that the site will be subjected to spray irrigation with secondarily treated sewage and that the consequent changes in the vegetation can be monitored by remote sensing.

Vegetation maps were constructed in early summer of all salt marshes in Rhode River (except those already mapped in 1971) by imposing current ground truth data on acetate tracings of available photographs. Since many marsh communities undergo seasonal variations in size, shape, and apparent composition, it was necessary to remap the marshes in the autumn. These seasonal changes made it difficult to predict the composition of all but the most homogeneous communities.

We spent most of the summer and autumn investigating and documenting the seasonality of salt marsh vegetation. In addition to repeated reconnaissance of all marshes in Rhode River, we closely examined the composition of three major plant communities in Hog Island marsh by stratified random sampling. From the samples we deduced the percentage of cover occupied by all species in these communities. We have not yet had time nor adequate equipment to compare the seasonal aspects of vegetation in each sample area. During 1972-73 we will broaden our sampling to include all marsh vegetation types.

We have attempted to determine how well our identification of marsh vegetation types by remote sensing will contribute to studies of primary productivity. Remote sensing has been used by Reimold (1971) to estimate the productivity of Georgia marshes. We invited Dr. Reimold to lecture at the Center about his methods and advise us as to their applicability to our marshes. We have used both Dr. Reimold's and Dr. Levin's (University of Pennsylvania) recommendations in correlating recent productivity measurements in Hog Island Marsh with our cover estimates and aerial signatures.

Our work in 1972-73 will concentrate on perfecting means of identifying marsh vegetation types by remote sensing, despite their seasonal variations. This work will be extended to marshes in other parts of the

Bay as necessary. After a reliable identification system has been developed, we will attempt to automate the recognition process by scanning microdensitometry. This method will be used to formulate a classification system for wetlands of the Chesapeake Bay.

STANDARDIZATION OF AUTUMN COLORATION CHANGES WITH MUNSELL COLOR CHIPS

In order to correlate species differences with leaf coloration changes, observations of vernal and autumnal phenology were made on hardwood trees throughout the Rhode River watershed in 1971. Difficulties were encountered in correlating these observations with aerial photographs, because of vignetting and other color fidelity problems in the aerial films, and because of variation in color ranges between trees of the same species and within individual trees. Moreover, the relative rates of color change varied within a season and from year to year. To control these difficulties, it was decided to compare crown coloration patterns with standardized Munsell color chips, a technique described by Heller et al, (1964) and by Krumpe et al (1971). Krumpe's method of overcoming the problem of intraspecific color variation was to differentiate "cluster ranges" of the most common colors within the "phase" or more variable range of colors characteristic of a species. This method was chosen for use at the Chesapeake Bay Center.

Although both Heller and krumpe used aerial photographs in their studies, it was decided to use 35mm ground photographs for at least the initial comparisons at the Chesapeake Bay Center, since these had proved to have better color fidelity and freedom from vignetting than the aerial films used. Moreover, it was essential to locate and identify precisely the individual trees being photographed. Since the entire crowns of trees had to be photographed, a 12 meter silo was chosen as the camera point. A series of overlapping photographs was taken around the horizon, using a Canon FT camera with Kodachrome II film (ASA 25), at approximately noon on clear days. One series was made during the third week in October and two more during the first and third weeks in November, to correspond with early, middle, and late stages of autumn coloration (autumn coloration was delayed in 1971 due to unusually warm weather).

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The photographs were developed commercially as 35mm slides. A set of tracings was made from them (an example of which is given in Figure 1) and the trees identified by symbols (Table 1).

The Munsell book of color was used to make the comparisons. The Munsell book contains a large number of opaque color chips arranged by equally spaced divisions of hue, value, and chroma. (The hue of a color is its relation to red, yellow, green, blue, or purple; the value indicates its lightness, and the chroma its strength or departure from neutral). Under the Munsell system, a color is recorded by numbers assigned to these three attributes, e.g., "5Y 8/6" indicates that the color has a hue of 5 Yellow, a value of 8 (on a scale from 2 to 9), and a chroma of 6 (on a scale from 1 to 14).

Comparisons between the Munsell chips and the 35mm slides were made by exposing equal areas of a color chip and a slide to the same light source, with the light being transmitted through the slide and reflected off the chip. This is basically the same method used by Heller and Krumpe, but technical details differed since each study used different types of film and different light sources. Heller also made 35mm slides of the Munsell color chips so that both the standard colors and the colors being determined could be viewed by transmitted light, but this technique was omitted from the present study because of possible changes in color fidelity when the slides were developed.

Since neither Heller nor Krumpe described their comparative devices, it was necessary to design one for the present study. Figure 2 is a sketch of the instrument. It was built of plywood and aluminum, and measures 9.2 cm deep, 10 cm wide, and 12.1 cm high, not including the eye shield and base. The unit supports a 35mm slide and a Munsell color chip side by side about 5 cm above the base, so that light may shine through the lower window and be

FIGURE 1.
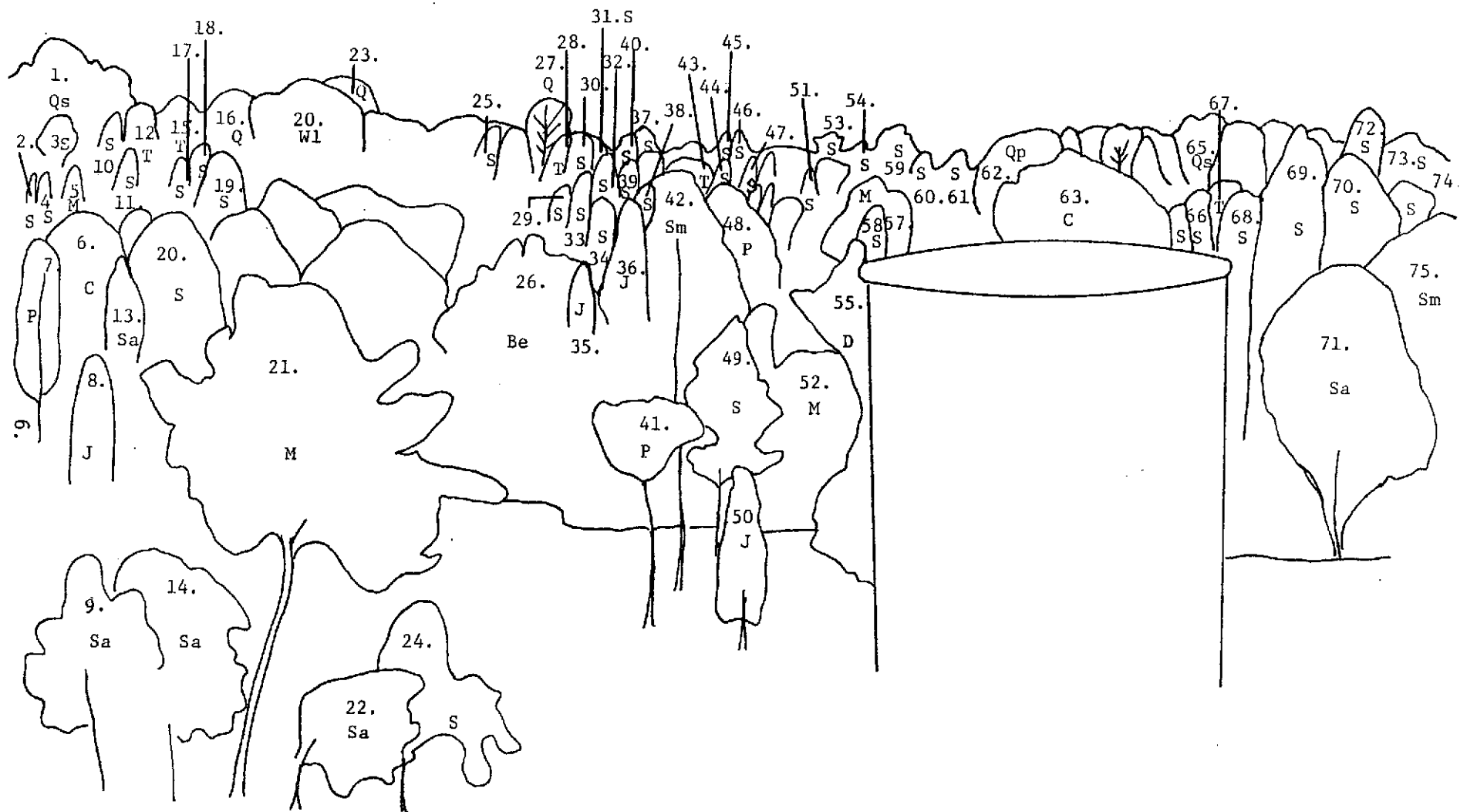
TABLE 1.

SYMBOLS USED FOR SPECIES OF TREES SHOWN IN FIGURE 1.

Be   Box elder (Acer negundo)

C   Cherry, black (Prunus serotina)

D   Dogwood, flowering (Cornus florida)

J   Juniper (Juniperus virginiana)

M   Maple, red (Acer rubrum)

P   Persimmon (Diospyros virginiana)

Q   Oak (Quercus sp.)

Qp   Pin oak (Quercus palustris)

Qs   Spanish oak (Quercus falcata)

S   Sweetgum (Liquidambar styraciflua)

Sa   Sassafras (Sassafras albidum)

Sm   Sycamore (Platanus occidentalis)

T   Tuliptree (Liriodendron tulipifera)

Wl   Willow, black (Salix nigra)

Figure 2.

COMPARATOR FOR MUNSELL CHIPS & 35MM. SLIDES
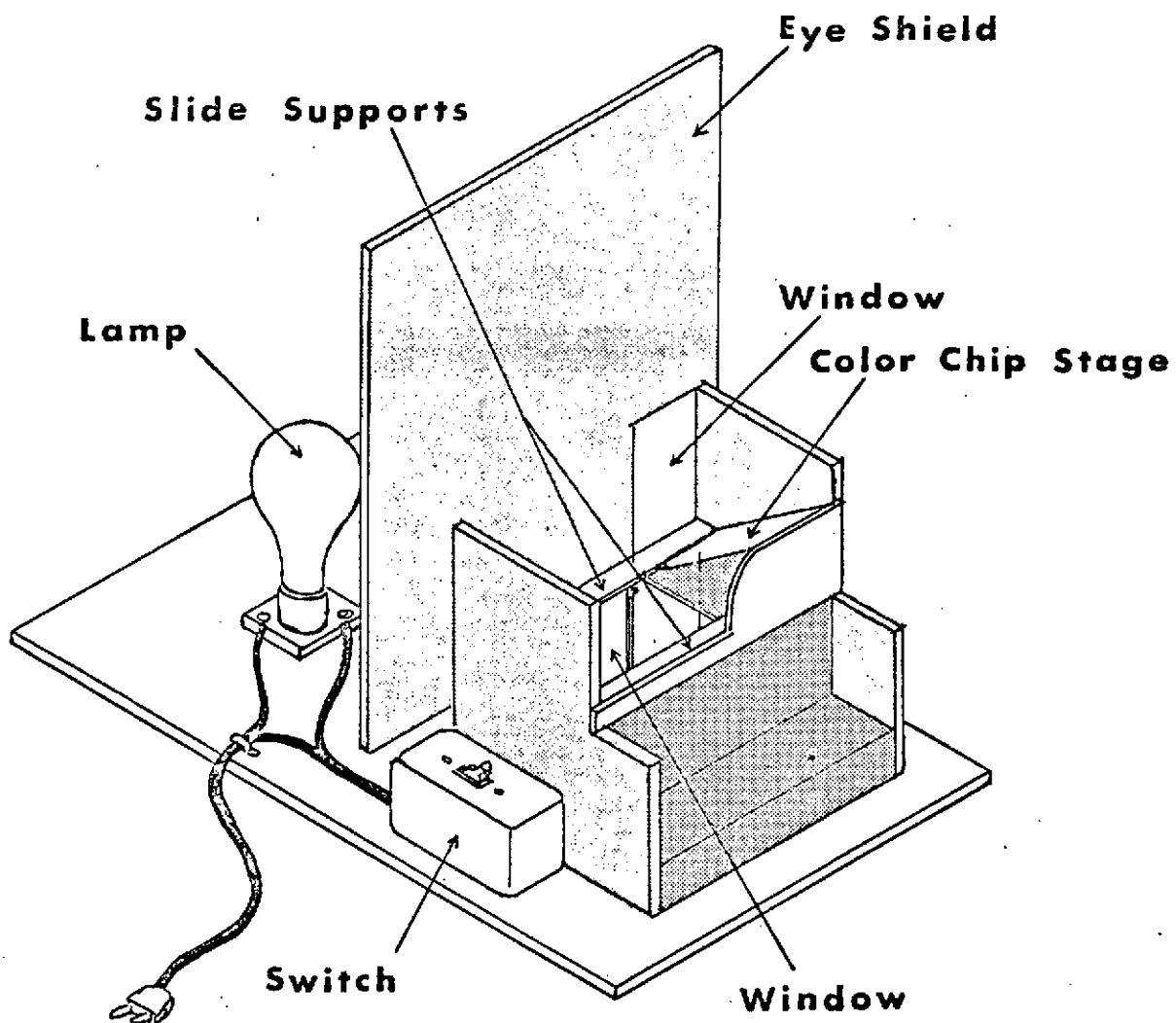
reflected upward through the slide. The upper window permits light from the same source to reach the Munsell color chip. The light source, a 250-watt blue photoflood lamp, (No. B1 superflood BCA, GE or Sylvania), is available at most camera shops. The color temperature of this lamp is 4800° K, so that when supplemented by natural daylight it produces a true coloration on daylight-type color films. Since the Munsell chips are designed to be viewed under natural daylight, they should also render accurate color when viewed under the lamp with a natural daylight supplement. It was impractical to use direct sunlight for the light source, since optimal sunlight conditions are seldom available here in winter. With the lamp as the primary light source, variations in the background daylight, because of haze or cloud cover, are not considered significant.

To use the instrument, a 35mm slide is placed on the slide supports and all parts except the tree being viewed are masked with black paper. A color chip is selected with the aid of the Munsell selection of Charts for Plant Tissues. This chip is placed beside the slide and marked except for an opening about as large as the tree being viewed. The slide and chip are then viewed vertically by a single interpreter. While a stereoscope is impractical for this comparison, a large magnifying lens proves useful to accentuate the colored leaves from background elements in the picture.

The ranges of observed colors are shown in Figures 3 to 6. Only two of the three series of slides (for early and middle autumn colors) have been examined to date. The relatively small sample size prevented as detailed a distinction of hue and chroma values as Krumpe's study used, but in the case of sweetgum, black cherry, and tuliptree in the late October series, enough trees were included to distinguish "cluster ranges" in which leaf colors most frequently fell. A cluster range was also discernible for sweetgum in the

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Figure 3.

MUNSELL COLOR COMPARATIVE DIAGRAMS
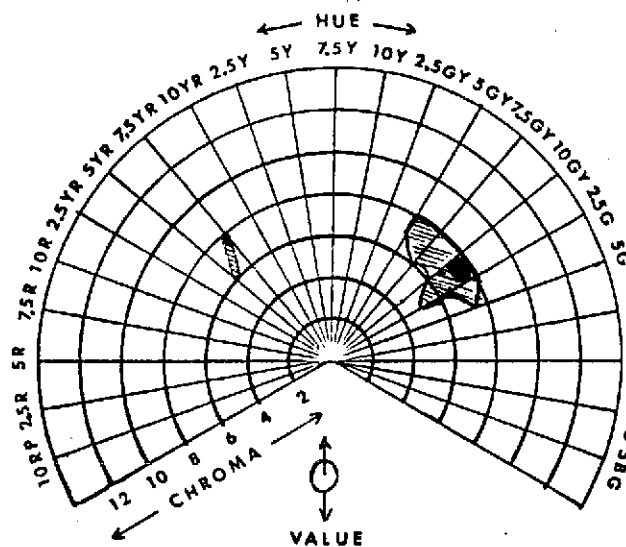
Sweetgum

Late October Series
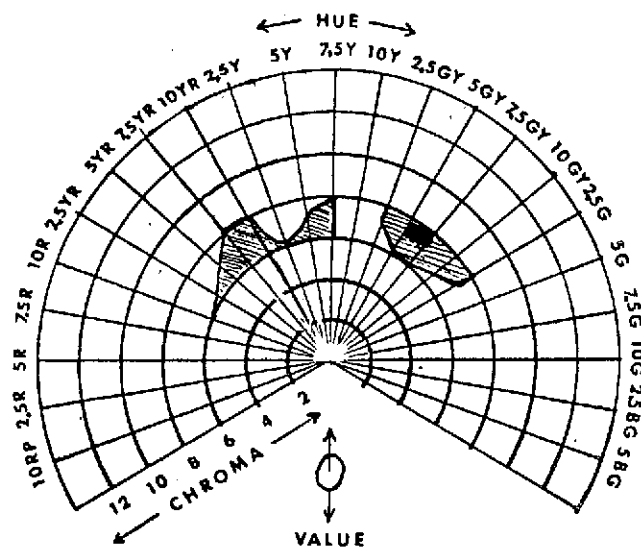
Sweetgum

Early November Series
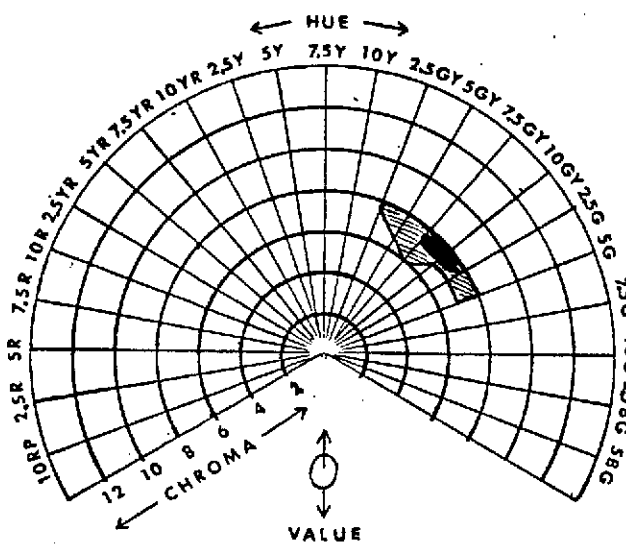
Tuliptree

Late October Series
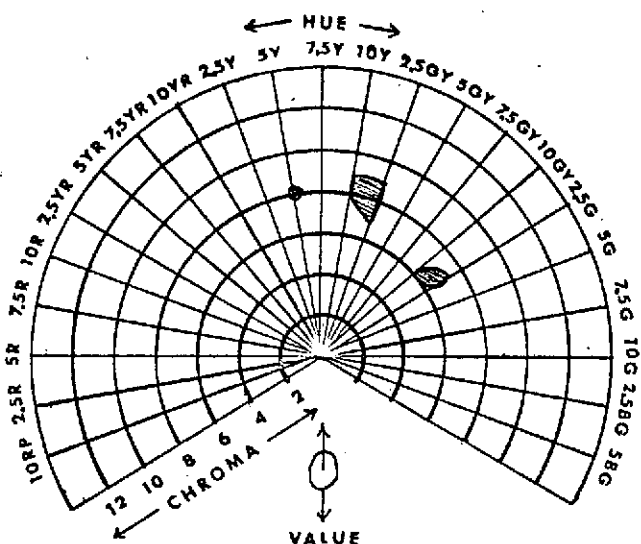
Tuliptree

Early November Series

Figure 4.

MUNSELL COLOR COMPARATIVE DIAGRAMS
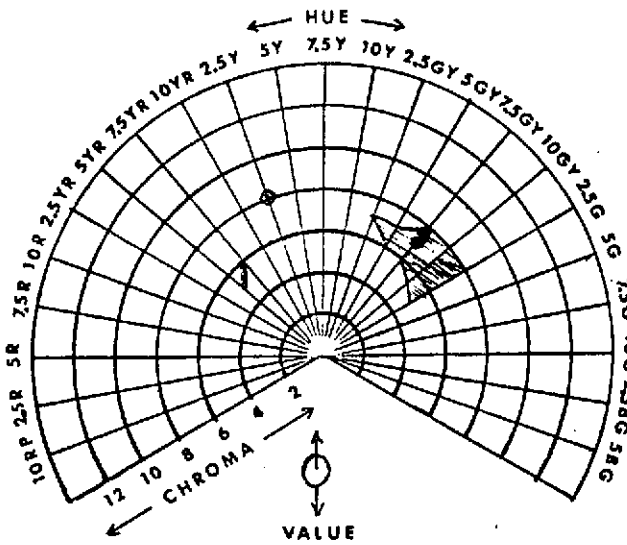
Black Cherry
Late October Series
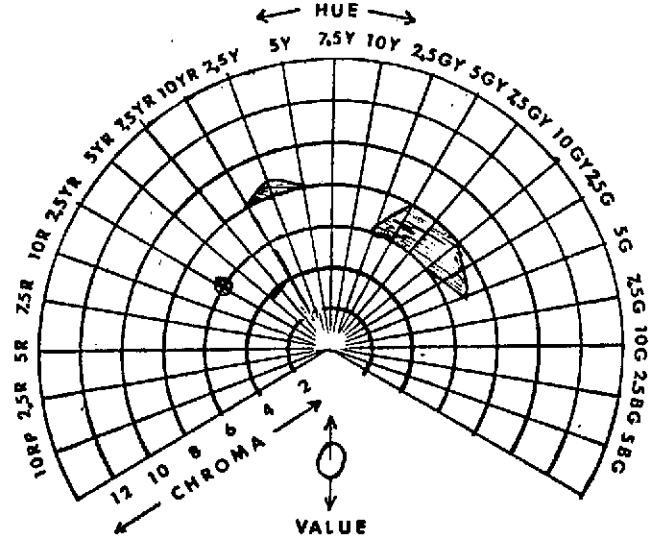
Black Cherry
Early November Series
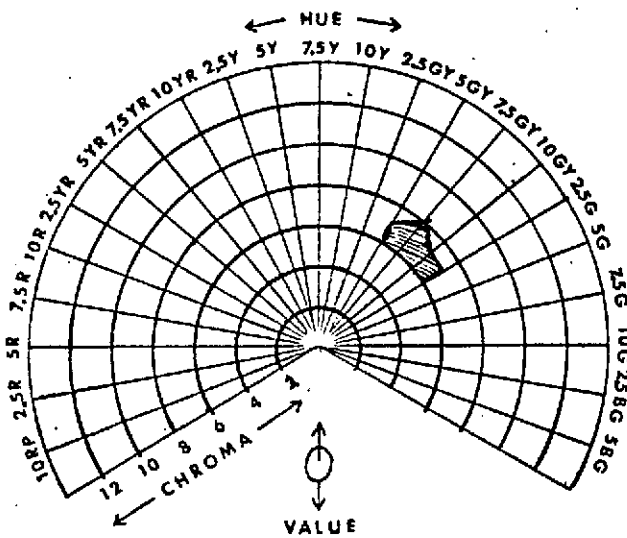
Red Maple
Late October Series
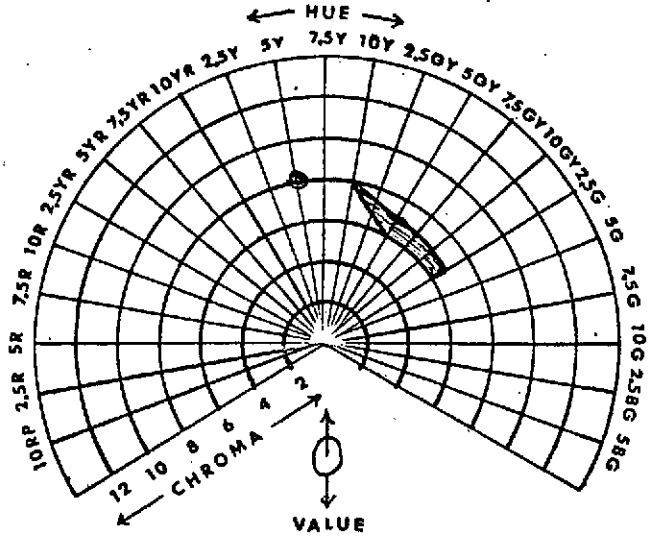
Red Maple
Early November Series

Figure 5.

MUNSELL COLOR COMPARATIVE DIAGRAMS
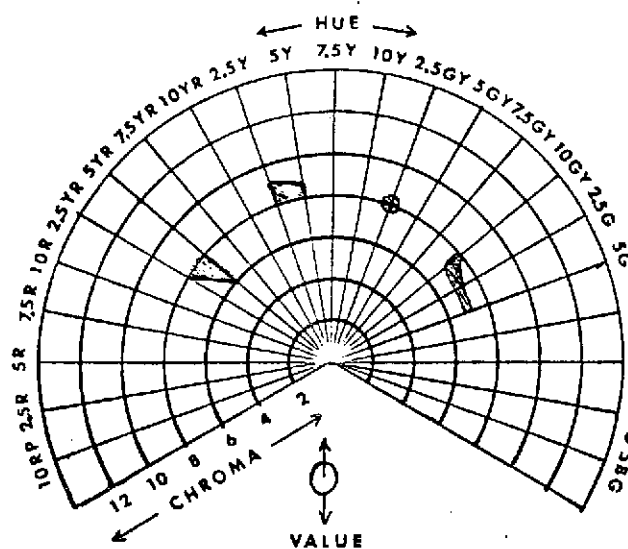
Sassafras
Late October Series
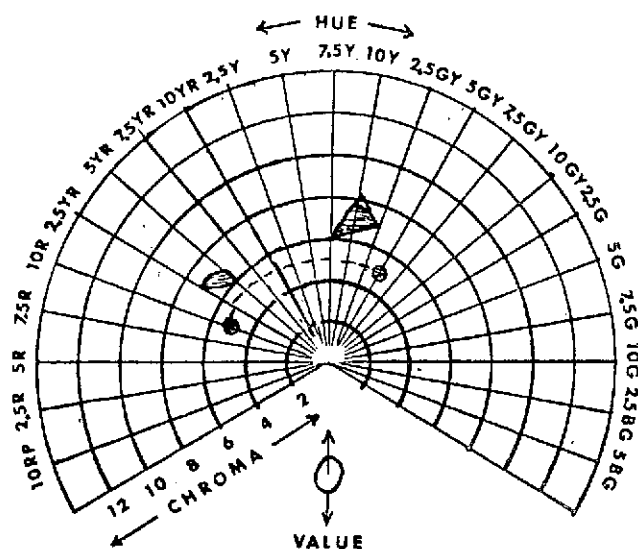
Sassafras
Early November Series
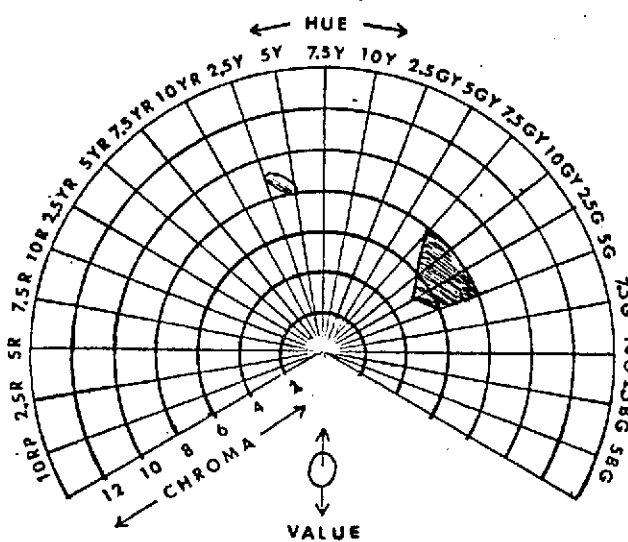
Spanish Oak
Late October Series
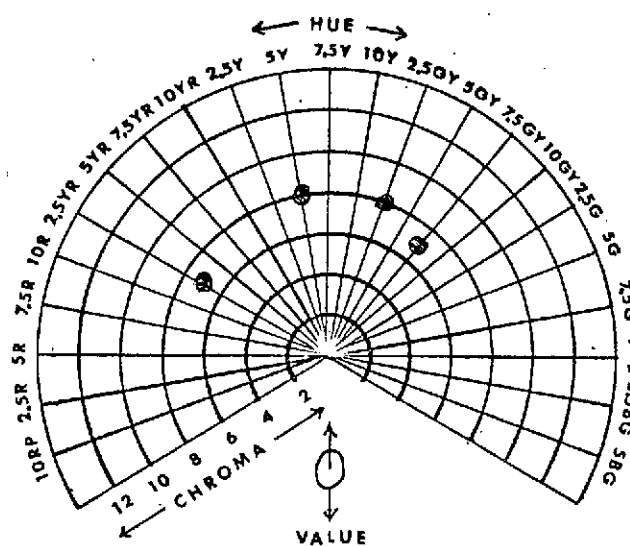
Spanish Oak
Early November Series

Figure 6.

MUNSELL COLOR COMPARATIVE DIAGRAMS
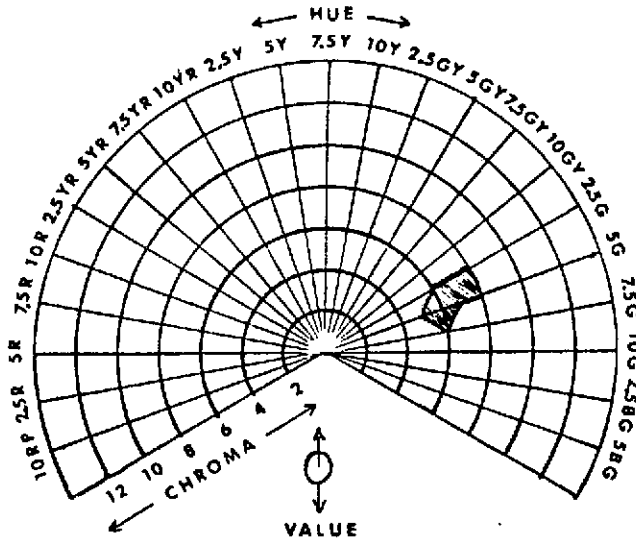
Virginia & Loblolly Pine
Late October Series
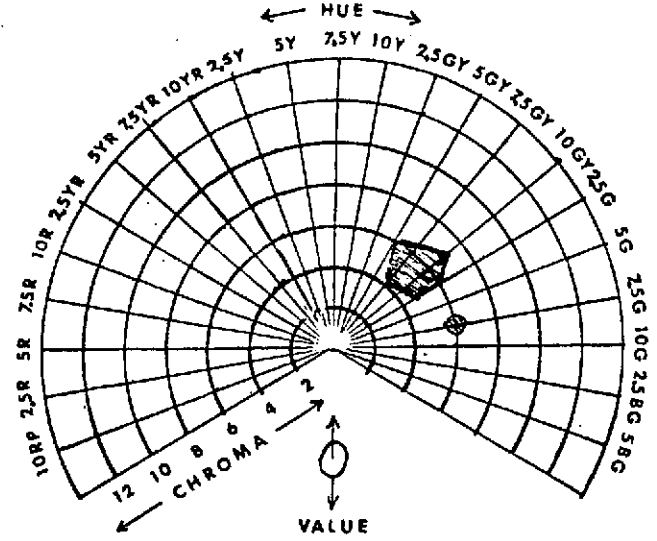
Virginia & Loblolly Pine
Early November Series
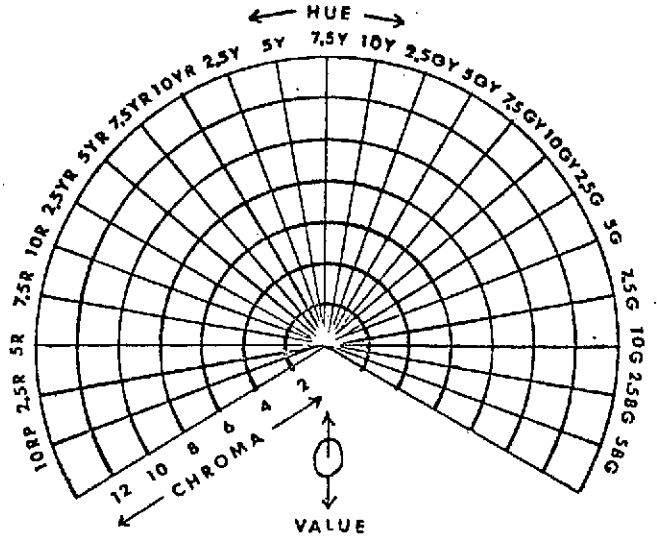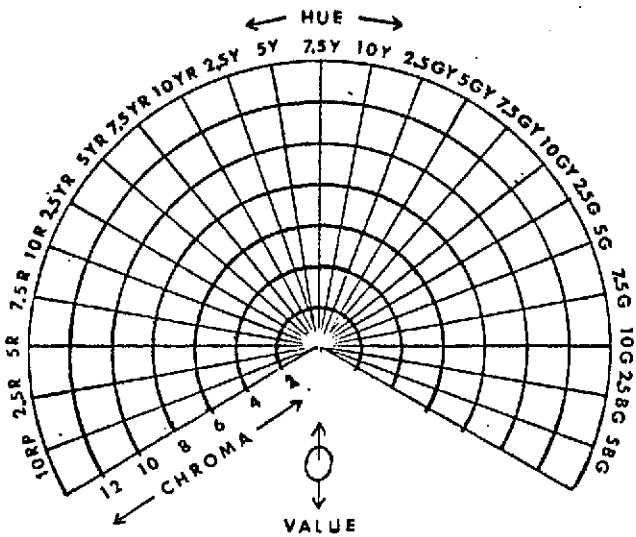
early November series. Although 19 species of trees are represented in the series, only 7 occurred frequently enough to permit meaningful color comparisons.

Since shaded portions of a crown proved to be about two hues darker and one step lower in value than unshaded portions, only trees which reflected direct sunlight on the photographs were selected for comparison with the Munsell chips. Variations in hue were even wider when part of a crown was back-lighted, but corresponding variations in value and chroma were relatively small. Several trees shown in both series exhibited enough side-lighting or back-lighting to eliminate them from evaluation, since they were located south of the camera point. Only slight variations in camera aperture were needed when the sequence of photographs was made, despite the movements of the camera in relation to the sun. Although Heller (1964) observed that chroma was susceptible to variation with differences in camera exposure, chroma variations within a species seldom exceed two steps. The exceptions were sweetgum and tuliptree, where variations were evenly distributed over four steps.

To measure color variation resulting from differences in lighting and camera exposure, color diagrams were drawn for loblolly and Virginia pine trees (Figure 6.). Although the actual coloration of these trees probably remained constant, pines in the late October series showed a variation of two steps in hue and three in value; in the early November series the variation was three steps in hue and three steps in value, with the hue moving toward a more yellow green color. This apparent variation in hue is difficult to explain, unless the proximity of hardwood trees with yellowing crowns contributed to a false evaluation. The variations in chroma may have resulted from camera exposure changes.

This exercise has shown that the use of Munsell color chips to define

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the ranges of autumn leaf coloration in hardwood trees is a promising technique, but circumstances in the present study made it unreliable for definitive correlations between leaf color and species. A major reason for this lack of reliability is the uncertainty of color fidelity in photographic film processing; this often changes the apparent color of the same tree from one frame to the next. This problem might be overcome if standardized color chips or ground panels could be photographed on the same film as the vegetation, so that any loss of color fidelity in the film processing would be readily detectable.

A second major problem is reliable correlation between ground identifications of individual trees and aerial photographs of the forest canopy. In the present study, this problem was solved by using a ground-based camera point, but then there were additional problems of small sample size and extreme sensitivity to sun angle. Forest areas selected for interpretation must be well marked out on the ground and close coordination established between the airplane crew and ground observers.

A third problem, which hampers comparison of identification techniques and results by different investigators is the lack of a single standard light source and instrumentation. Consequently, the crown identification data collected by Heller (1964) and Krumpe (1971) may not be comparable with ours.

If these problems can be overcome, further experiments with Munsell color comparison should be undertaken using 22.9 x 22.9 cm transparencies instead of 35mm slides. A reliable means of identifying forest canopy coloration is greatly needed, and the Munsell technique is currently the only standard for comparison of colors.

In the spring, 1972, a decision was made to utilize abandoned fields at the CBCES for disposal of secondarily-treated domestic sewage by means of a spray irrigation system. Thus, there developed the opportunity to study the effects of controlled application of treated sewage on the vegetation of abandoned fields using remote sensing techniques. One prerequisite of such a study is the mapping and description of existing vegetation at the proposed site before any effluents are discharged. This preliminary work was completed in early June.

Almost all of the proposed irrigation site lies above the 15.24 m contour; it is relatively level, and has steep, forested sides sloping toward Muddy Creek and the Rhode River. Approximately half of its 1 hectare is proposed for irrigation.

The vegetation map (Fig. 7), drawn over a base map derived from aerial photographs, indicates the composition of the plant communities. Natural color photos taken in July (Flight 73) were best in showing the patterns of summer vegetation, and an infrared film taken in April (Flight 51) best showed the unpaved roads and pine stands masked during summer. The base map was prepared using a frame from the July film enlarged to a scale of approximately 1:3,850. An acetate tracing was then made of the vegetation patterns. A frame from the April film was similarly enlarged and superimposed on the tracing to show the roads.

Seven of the ten vegetation types in Fig. 7 represent variations of immature forest canopy, and three represent ground cover of unforested area. The vegetation types were described on the basis of those species visible on aerial photographs. A detailed analysis of the vegetation within each of the cover types, including biomass, density, and frequency, will be made when the irrigation system is built.

PROPOSED SPRAY IRRIGATION SITE

Legend:
- Brambles Honeysuckle
- Young Pine
- Beech/Dogwood (Ravine)
- Lespedeza
- Hickory, Oak, Tulip, Pine
- Mixed Young Hardwoods (no Pine)
- Grass and Weeds
- Dense Young Sweetgum
- Mixed, Young Hardwoods/Pine
- Sweetgum, 1-2 other Hardwoods

FOREST

MUDDY CREEK

FOREST

-N-

100m

17.
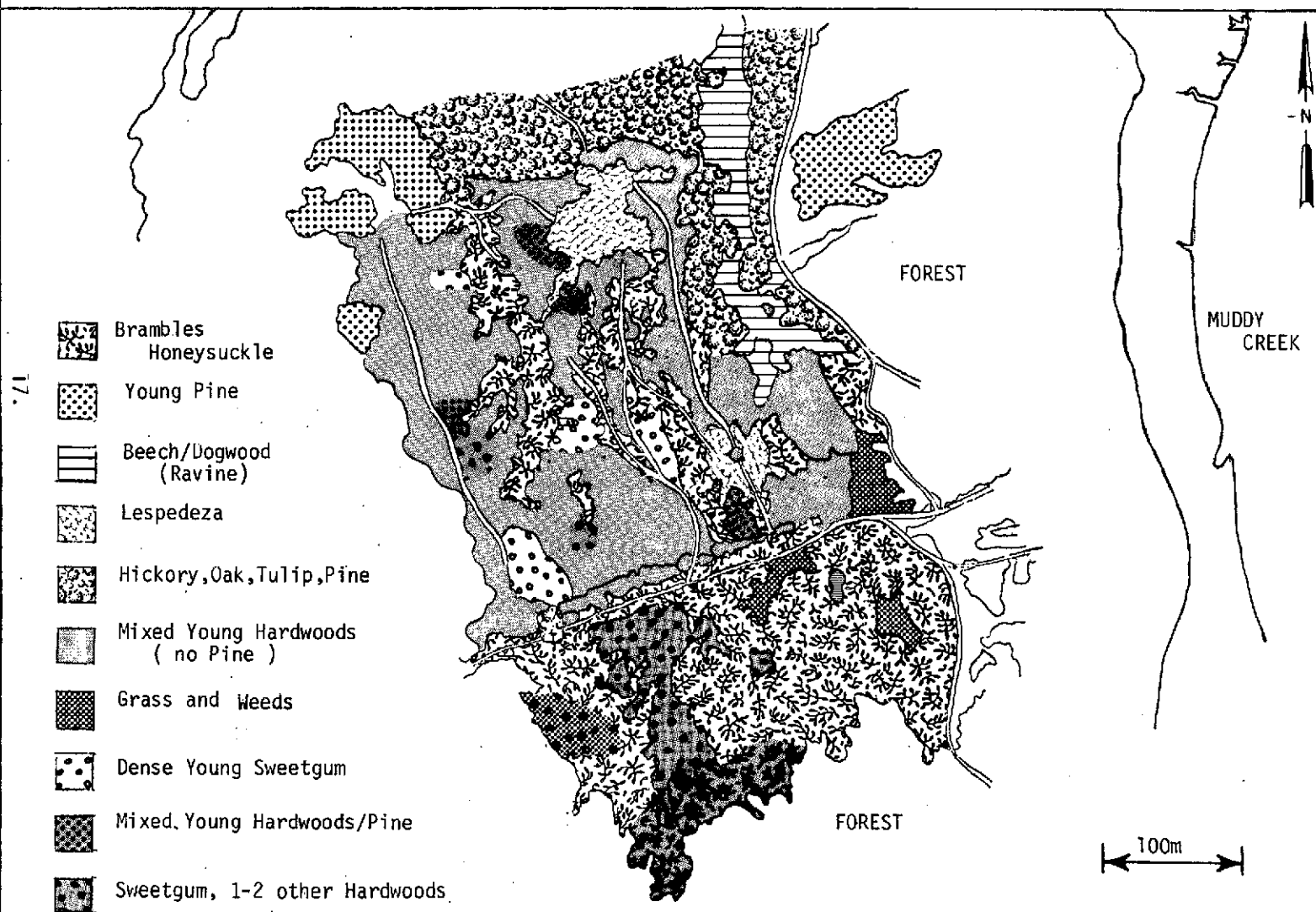
Figure 7.

INTERPRETATION AND VERIFICATION OF SALT MARSH VEGETATION TYPES
BY REMOTE SENSING

The increased emphasis being given to the role of salt marshes, particularly in estuarine metabolism, by both NASA and investigators in the Rhode River Program, as well as the need to consolidate skills in the identification of marsh plants, acquired in 1971, prompted a new exercise in the interpretation and mapping of this vegetation. This has enabled us to evaluate the usefulness of photographs taken at different seasons for identifying species of marsh plants, and to check the accuracy of our own identifications. Vegetation maps of three salt marshes in Rhode River and one in West River, now in great demand by investigators in the Rhode River Program, were developed.

The four marshes chosen border Sellman, Bear Neck, and Fox Creeks in Rhode River, and Cheston Creek in West River. Although floristically similar, the composition and distribution of vegetation types is quite different. A similar study will be made of the remaining salt marshes in Rhode River later this summer.

The first step in the project was to trace all discernible vegetation patterns in each marsh from natural color photographs. Those taken in April (flight 51) and November (Rome flight 71-67) were selected to permit a comparison of seasonal differences in discernible patterns. The vegetation types and actual species composition of each were independently interpreted by Higman and Weck. Most of the predictions were made from the same frames of April and November films used for mapping, but the photos taken in June 1970 (flight 15) and July 1971 (flight 73) were also consulted.

The predicted vegetation types on the maps were then compared with the actual situation in the field, and detailed descriptions were made. The descriptions include estimated percentages of the areas covered by those species which should be visible on an aerial photograph. Criteria such as biomass, density, and frequency were not considered necessary; a more precise determination of the floristic composition can be made later. The field notes were then synthesized into descriptions of 20 vegetation cover types. Most of these were common to all marshes; thus the same pattern could be used to represent a particular type of vegetation on all maps.

While several contiguous parts of a marsh may have similar vegetation, as in the Sellman Creek and Cheston Point marshes, these parts differ in species composition to the extent that they are discernible on an aerial photograph. This difference does not justify designation as distinctive vegetation types.

The predictions made of the types of marsh vegetation were compared not only with the actual vegetation types, but with the films from which each prediction was originally based. Each investigator graded the other on the relative accuracy of each identification, and tables were made for each marsh. These results were combined (Table 2) to show the relative success of each observer in identifying 16 different vegetation types. We had little or no success in predicting four vegetation types not previously encountered. These are omitted from Table 2.

The data obtained from flight 51 (April) and Rome flight 71-67 (November) were most useful for the identification of vegetation types, since films from these had been selected for the base maps. Data from flights 15 (June) and 73 (July) were consulted only as supplements. The decision to use a particular film was made independently by each observer.

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TABLE 2

RELATIVE SUCCESS OF IDENTIFICATION OF SALT MARSH VEGETATION TYPES

Observers: W=Weck, H=Higman
Numbers in parentheses are no. of correct or partial identifications
per no. of attempts using each film.

Vegetation Type	Flight 51 (Apr.	Flight 15 (June	Flight 73 (July	Flight 71-67 (Nov.
Phragmites communis 100%	W: 100% (1 of 1 H: not used	H: 0% (0 of 2	not used	W: 100% (1 of 1 H: 0% (0 of 2
Typha angustifolia 60-100%	W: 0% (0 of 2 H: 0% (0 of 4	W: not used H: 0% (0 of 2	W: 33% (1 of 3 H: 50% (2 of 4	W: 37% (3 of 8 H: 20% (1.5 of 8
Iva frutescens 80-100%	W: 100% (1 of 1 H: 100% (2 of 2	W: not used H: 66% (2 of 3	W: 100% (1 of 1 H: 100% (1 of 1	W: 80% (4 of 5 H: 75% (3 of 4
Iva 60-90%, Distichlis/Spartina patens 10-40%	W: 75% (2 of 2 H: 50% (1 of 1	W: not used H: 90% (6.5 of 7	W: 75% (2 of 2 H: 75% (2 of 2	W: 75% (10 of 14 H: 78% (14 of 18
Iva 60-90%, Distichlis/Scirpus olneyi 10-40%	W: 75% (1 of 1 H: not used	not used	not used	W: not used H: 50% (2 of 2
Iva 20-50%, Distichlis/Spartina patens 50-80%	W: not used H: 50% (1 of 2	W: not used H: 50% (2 of 2	W: not used H: 75% (2 of 2	W: 25% (2 of 4 H: 50% (3 of 3
Iva 10-20%, Spartina patens 80-90%	W: not used H: 100% (1 of 1	not used	W: 0% (1 of 1 H: 100% (1 of 1	W: 80% (1 of 1 H: 25% (1 of 1
Distichlis and/or Spartina patens and/or Eleocharis halophila 70-100%	W: 50% (2 of 4 H: 100% (2 of 2	not used	not used	W: 33% (2 of 6 H: 30% (5 of 9
Iva 60-70%, Spartina alterniflora 10-20%	W: not used H: 65% (1 of 1	not used	W: 65% (1 of 1 H: 65% (1 of 1	not used
Spartina alterniflora 70-100%	W: 30% (1 of 2 H: not used	W: not used H: 75% (1 of 1	not used	W: 50% (1 of 2 H: 50% (4 of 6
Spartina alterniflora 50%, S. patens 50%	not used	not used	not used	W: not used H: 70% (1 of 1
Scirpus olneyi 60-90%, Distichlis 10-20%	W: 40% (2 of 5 H: 25% (1 of 1	W: not used H: 25% (1 of 1	W: 0% (0 of 1 H: not used	W: 33% (2 of 6 H: 20% (3 of 6
Scirpus 40-60%, Distichlis/Spartina patens 30-50%	W: not used H: 50% (1 of 1	not used	W: 50% (1 of 1 H: 30% (1 of 1	W: 75% (2 of 2 H: not used
Iva and/or Baccharis halimifolia 70-100%	not used	W: not used H: 50% (2 of 4	not used	W: 33% (1 of 3 H: 20% (1 of 5
Baccharis 80-100%	not used	not used	not used	W: not used H: 0% (0 of 1
Trees & Shrubs	W: 100% (1 of 1 H: not used	W: not used H: 75% (3 of 4	not used	W: 50% (1 of 2 H: 17% (1 of 6

There seems to be relatively little difference in the value of films taken in April, July, and November for the identification of _Iva frutescens_ and vegetation types in which it is prominent, judging by the success of both observers in identifying this species. The bushy habit of _Iva_ is conspicuous. Low matted grasses (_Distichlis spicata_, _Spartina patens_) are best identified using the April film, although not enough identifications were made to make this conclusion certain. Photographs taken in April or November were equally useful for identifying _Scirpus olneyi_ and _Spartina alterniflora_.

Difficulty was encountered in distinguishing short grass (_Distichlis/ Spartina patens_) from moderately tall grass (_Spartina alterniflora_) or sedge (_Scirpus olneyi_), especially since these species have been found in sympatry. _Scirpus_ was occasionally confused with cattail (_Typha angustifolia_), or with dead _Iva frutescens_. In both instances, the photographs taken in November were more difficult to interpret.

Iva, _Phragmites communis_, and _Typha angustifolia_, in that order, were the most distinctive. _Phragmites_ was identifiable on both the April and November films, while photos taken in July and November were best for _Typha_. Neither species occurred frequently or over large areas, except _Typha_ in the Sellman Creek marsh. The communities of shrubs and stunted trees in the Bear Neck Creek and Cheston Point marshes were also distinctive, although sometimes difficult to distinguish from _Iva frutescens_.

SEASONALITY IN THE MARSH VEGETATION OF RHODE RIVER

The marshes of Rhode River exhibit distinct vegetation changes within the summer growing season. When the marsh vegetation is fully leafed out, in early summer, the vegetation may either change color and texture or become obscured by late flowering perennials, annuals, or epiphytes. By late summer, once-familiar vegetation in the field and on aerial photos becomes less so to the observer. For this reason, it has become necessary to map the marshes at both ends of the growing season for accurate interpretation of aerial photographs and for adequate understanding of marsh vegetation dynamics. A generalized Rhode River marsh is presented in Figures 8 and 9. Figures 10 through 28 are maps of all of the major marshes at Rhode River, depicting seasonal variations observed.

Natural color transparencies were chosen from both early and late summer flights and the vegetation patterns for each marsh traced onto acetate for use as base maps in the field. These were then revised in the field. The primary changes in vegetation from early to late summer in Rhode River that can be detected on aerial photos are:

1. stem elongation and flowering of:

   Typha angustifolia, _Phragmites communis_, _Spartina cynosuroides_

2. lush vertical growth, leafing, flowering, and reddening of stems of:

   Acnida cannabina

3. thin to lush covering growth and flowering of:

   Lythrum lineare, _Ptilimnium cappillaceum_, _Polygonum hydropiperoides_,

   Mikania scandens, _Cuscuta sp._, _Slirpus pbustus_

4. spotty, sometimes clumped, vertical growth and flowering of:

   Hibiscus palustris, _Kosteletzkya virginica_, _Solidago sempervirens_,

   Pluchea camphorata

5. lush, vertical growth, leafing, flowering: _Panicum virgatum_

22.

THE MOST MARKED CHANGES IN THE INDIVIDUAL MARSHES IN RHODE RIVER ARE AS FOLLOWS:

	Early Summer	Late Summer
Hog Island Marsh:	Small patch Spartina alterniflora	Covered by Ptilimnium cappillaceum, Lythrum lineare, and Polygonum hydropiperoides
	Large patch of Spartina alterniflora	Covered by Acnida cannabina
	Whole Marsh	Interspersed with Hibiscus palustris, Kostoletzkya virginica, and Solidago sempervirens
Bear Neck Creek Marsh:	Spartina alterniflora	Covered by Hibiscus palustris in flower
	Whole marsh	Interspersed with Hibiscus palustris, Kostoletzkya virginica, and Solidago sempervirens
Cheston Point Marsh:	Typha angustifolia, Iva frutescens, and Distichlis spicata/spartina patens mixture	Overshadowed by fall flowering annuals and perennials
	Whole marsh	Interspersed with Hibiscus palustris, Kostoletzkya virginica and Solidago sempervirens
Sellman Creek Marsh:	Shrubs and dead trees	Covered by Mikania scandens
	Scirpus Olneyi	Covered by Scirpus robustus
	Distichlis spicata/Spartina patens	Overgrown with Scirpus Olneyi
	Scirpus Olneyi	Covered by Polygonum hydropiperoides
	Spartina alterniflora	Covered by Acnida
	Whole marsh	Interspersed with Hibiscus palustris, Kostoletzkya virginica, and Solidago sempervirens

Fox Creek Marsh:	Whole Marsh	Interspersed with <u>Hibiscus palustris</u>, <u>Kostoletzkya virginica</u>, and <u>Solidago sempervirens</u>
Kirkpatrick Marsh:	No basis for comparison yet	

While the flowering <u>Hibiscus palustris</u> and <u>Kostoletzkya virginica</u> do not generally cover the vegetation around them in late summer, their large, conspicuous blossoms, especially in the former, can create puzzling textural as well as tonal changes in once-familiar vegetation patterns. Marsh goldenrod (<u>Solidago sempervirens</u>) can similarly confuse the photointerpreter unless he is aware of its presence; in small concentrated clumps, the flowers of this plant appear very bright yellow on natural color aerial transparencies.

It is easy to anticipate changes in color and texture due to the flowering of the ever-present tall marsh grasses, <u>Typha</u>, <u>Phragmites</u>, and <u>Spartina cynosuroides</u>. Plants such as <u>Acnida cannabina</u>, <u>Pluchea camphorata</u>, <u>Lythrum lineare</u>, <u>Ptilimnium cappillaceum</u>, and <u>Polygonum hydropiperoides</u>, however, are cryptic until their late summer stem elongation and flowering. These plants appear tiny and insignificant in spring and early summer and are generally overlooked, indeed unseen, by the field observer estimating cover.

From our work here in Rhode River, we have found that knowledge of vegetation changes within the growing season is essential to identification of marsh types from aerial photographs and to understanding of marsh ecosystem dynamics.

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FIGURE 8

GENERALIZED RHODE RIVER MARSH

WATER

WATER

LAND
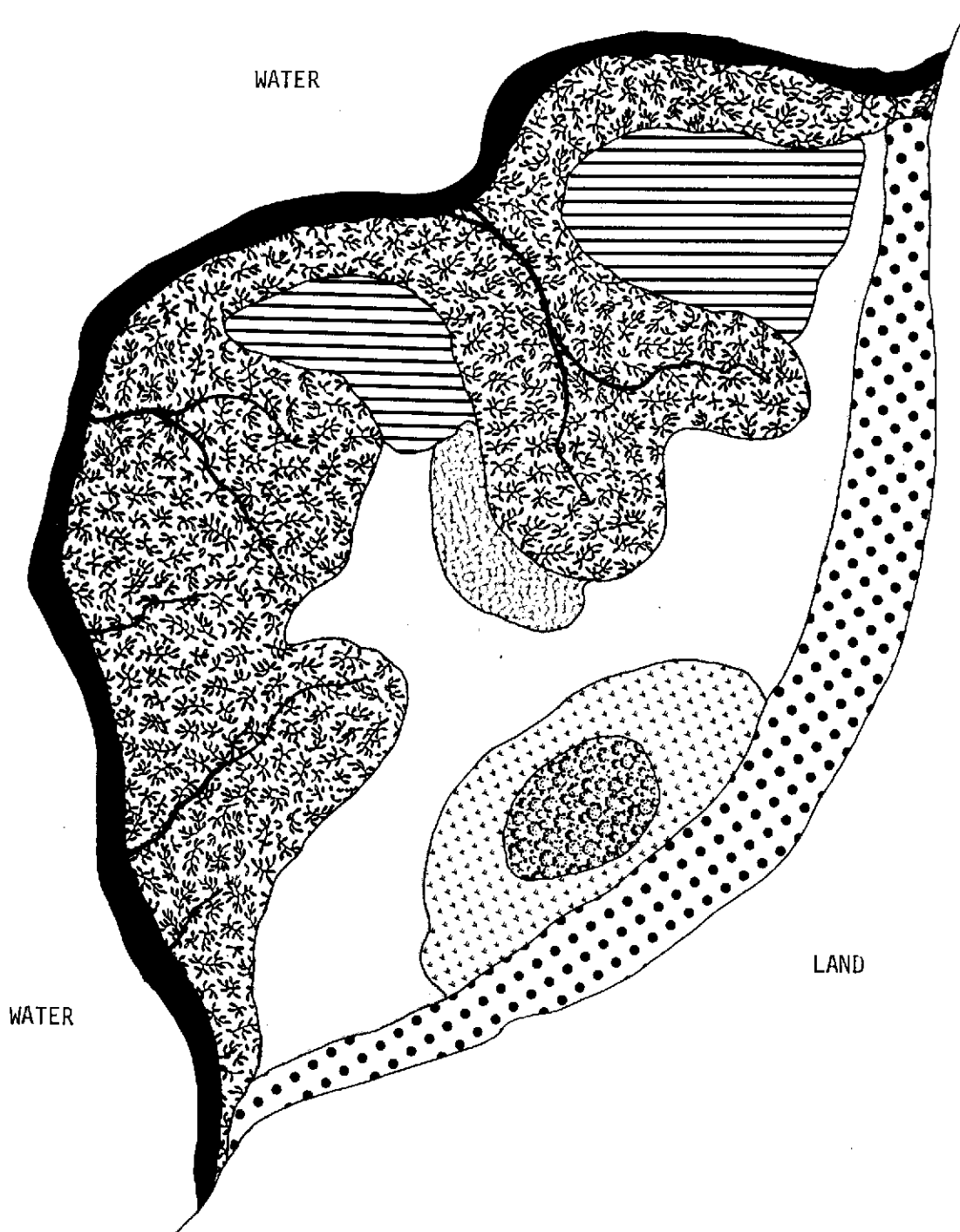
FIGURE 9

GENERALIZED RHODE RIVER MARSH - KEY

		Frequent Associates
⊡	Typha angustifolia	Spartina cynosuroides, Hibiscus palustris
■	Spartina alterniflora	Acnida cannabina, Spartina cynosuroides
▢	Distichlis spicata/ Spartina patens	Scirpus Olneyi, Hibiscus palustris
▤	Scirpus Olneyi	Distichlis spicata/Spartina patens
▦	Iva frutescens	Distichlis spicata, Baccharis halimifolia, Spartina alterniflora
▨	Phragmites communis	
▨	Panicum virgatum	Thelypteris palustris, Scirpus Olneyi, Distichlis spicata/Spartina patens
▓	Shrubs and small trees	Baccharis halimifolia, Panicum virgatum, Thelypteris palustris

HOG ISLAND MARSH - EARLY SUMMER ASPECT

TREES

TREES

MUDDY CREEK

HOG ISLAND

MUDDY CREEK

N

100m

FIGURE 10

FIGURE 11

Typha angustifolia 70 - 100%

Spartina alterniflora 60 - 100%

Spartina alterniflora 50%, Iva frutescens 20%, mud/water 20%, Spartina cynosuroides 10%

Iva frutescens 50 - 100%

Spartina cynosuroides 80 - 100%

Iva frutescens 40%, Spartina cynosuroides 40%

Scirpus Olneyi 70 - 90%

Iva frutescens 50%, Scirpus Olneyi 30%

Distichlis spicata/Spartina patens 60 - 100%

Distichlis spicata/Spartina patens 60%, Scirpus Olneyi 40%

Phragmites communis 80 - 100%

Panicum virgatum 80 - 100%

Shrubs and small trees

DISTRIBUTION OF COVER SAMPLES
HOG ISLAND MARSH - LATE SUMMER

TREES

TREES

MUDDY CREEK

HOG ISLAND

MUDDY CREEK

N

100 m
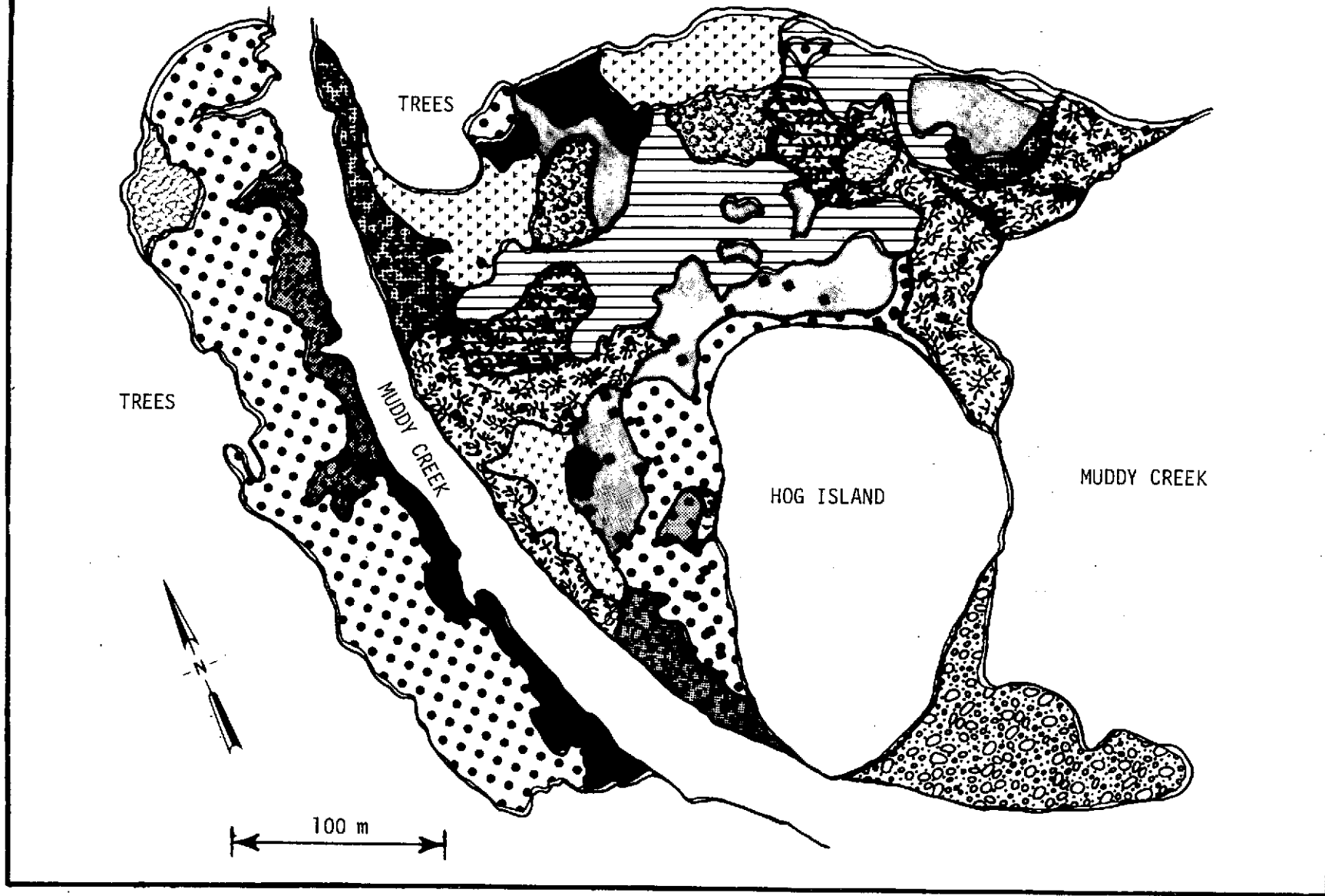
FIGURE 12

FIGURE 13

HOG ISLAND MARSH - LATE SUMMER KEY

Phragmites communis 80 - 100%

Typha angustifolia with scattered Hibiscus palustris 70 - 100%

Distichlis spicata/Spartina patens 60 - 100%

Distichlis spicata/Spartina patens 60%, Scirpus Olneyi 40%

Scirpus Olneyi 70 - 90%

Acnida cannabina 90 - 100%

Spartina alterniflora 60 - 100%

Spartina alterniflora 30 - 40%, Iva frutescens 10 - 20%, Acnida cannabina 20 - 40%

Spartina cynosuroides 80 - 100%

Iva frutescens 50 - 100%

Iva frutescens 40%, Spartina cynosuroides 40%

Iva frutescens 50%, Scirpus Olneyi 30%

Panicum virgatum 80 - 100%

Ptilimnium cappillaceum 70 - 80%, Polygonum hydropiperoides/Spartina alterniflora 20 - 30%

Polygonum hydropiperoides 80%, Spartina alterniflora 20%

Lythrum lineare 60%, Polygonum hydropiperoides 40%

Shrubs and small trees

KIRKPATRICK MARSH
LATE SUMMER ASPECT

TREES
(CORN ISLAND)

MUDDY CREEK

BOATHOUSE
CREEK

TREES

TREES

-N-

100 m
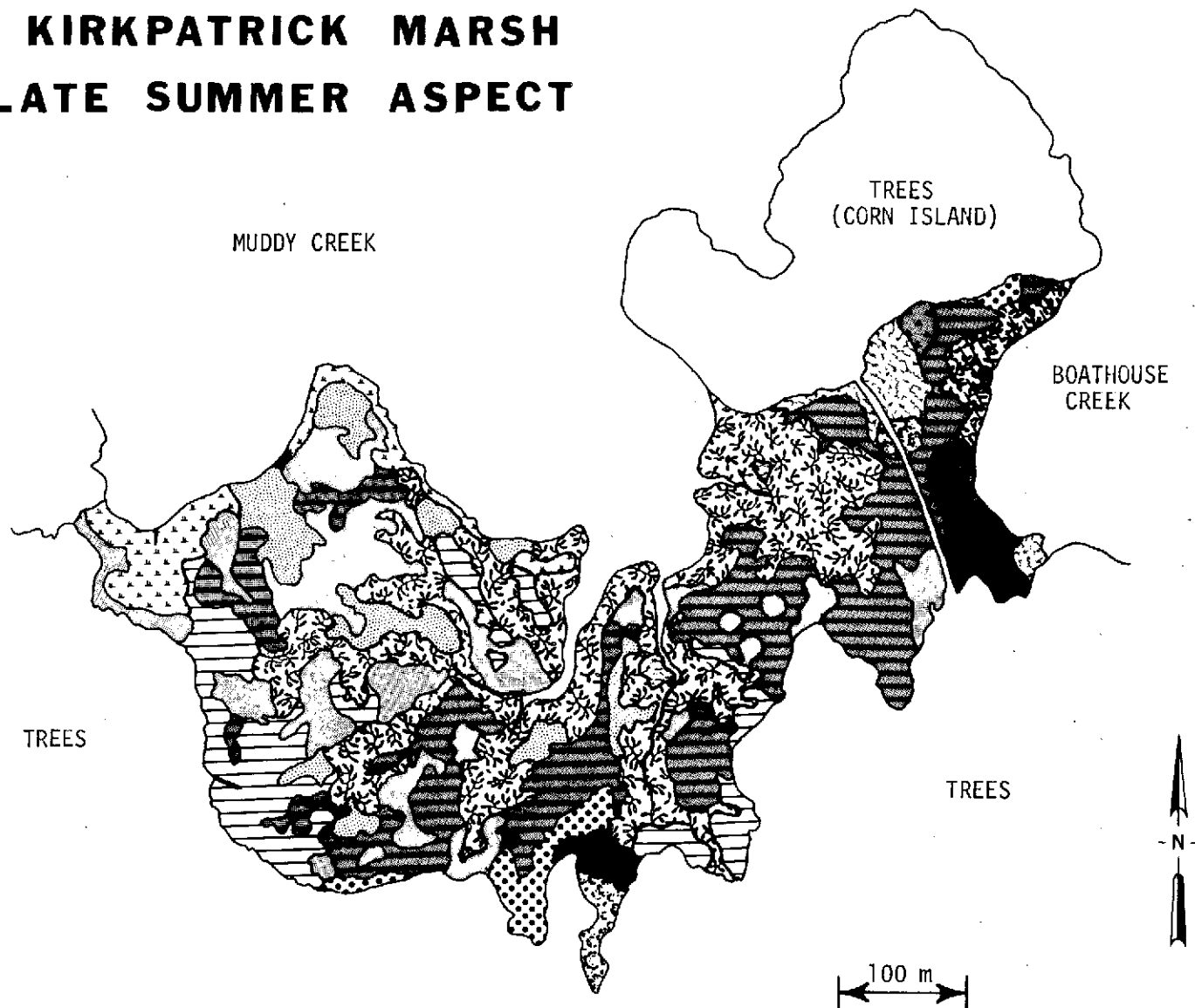
FIGURE 14

FIGURE 15

KIRKPATRICK MARSH - LATE SUMMER KEY

Typha angustifolia 80 - 100%

Phragmites communis 70 - 100%

Panicum virgatum 40 - 75%

Spartina cynosuroides 60 - 90%

Spartina patens/Distichlis spicata 60 - 100%

Spartina patens/Distichlis spicata 50%, Panicum virgatum 50%

Scirpus Olneyi 50 - 100%

Scirpus Olneyi 35 - 50%, Spartina patens/Distichlis spicata 35 - 50%

Iva frutescens 20 - 40%

Iva frutescens 40 - 75%

Iva frutescens 70%, Distichlis spicata/Scirpus Olneyi 30%

Iva frutescens 50%, Distichlis spicata/Scirpus Olneyi/
Phragmites communis 50%

Iva frutescens 60%, Spartina patens/Distichlis spicata and
Spartina alterniflora 40%

Shrubs and small trees

FIGURE 16

BEAR NECK CREEK MARSHES

RIVER
CLUB
ESTATES

HOLLY
HILLS
INLET

BEAR
NECK
CREEK
HEADWATERS

TREES

-N-

DEVELOPED

BEAR

NECK

CREEK

TREES

BEAR
NECK
CREEK
MARSH

TREES

Marshes

200 m
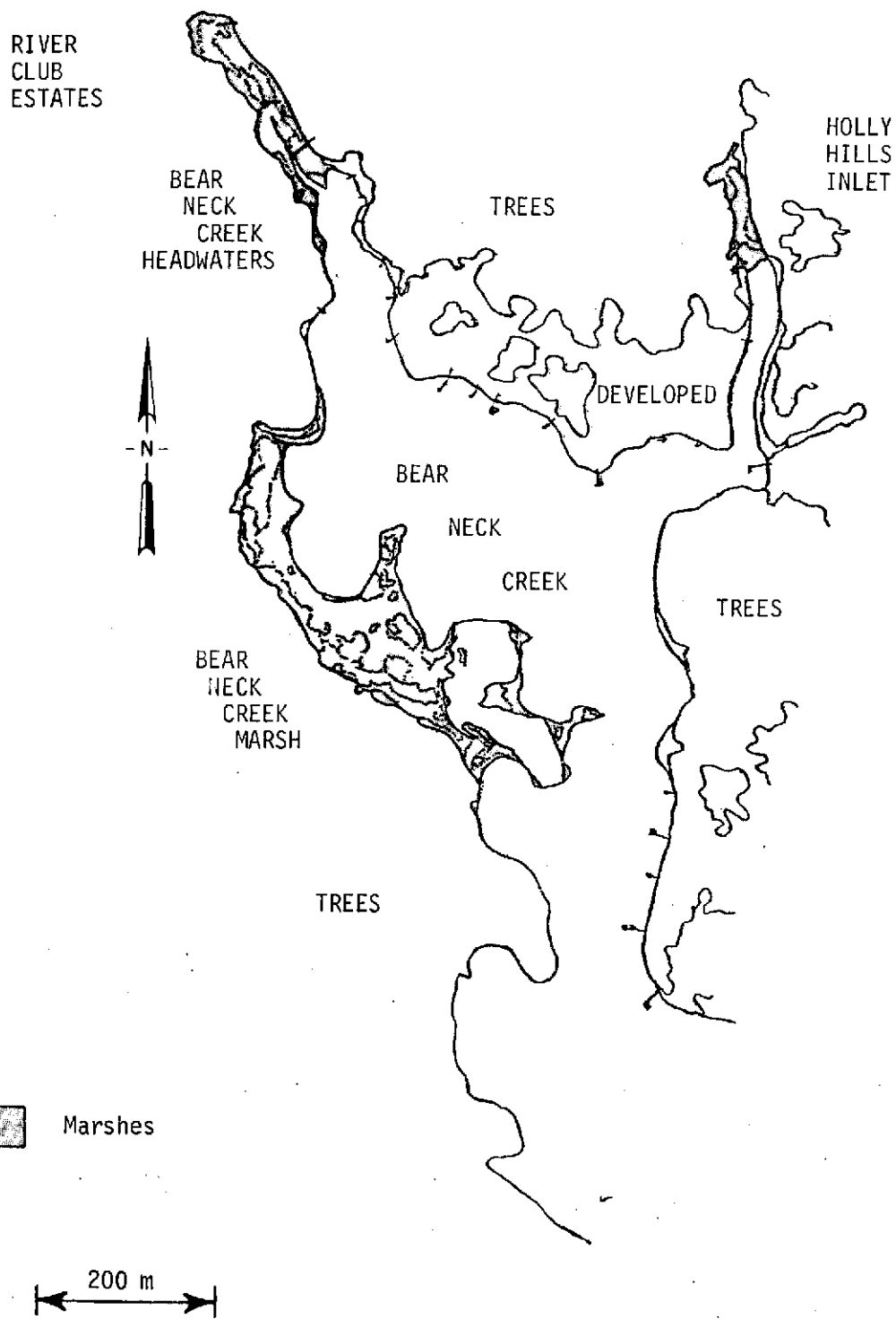
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BEAR NECK CREEK MARSH
EARLY SUMMER ASPECT

BEAR NECK CREEK

TREES

TREES

-N-
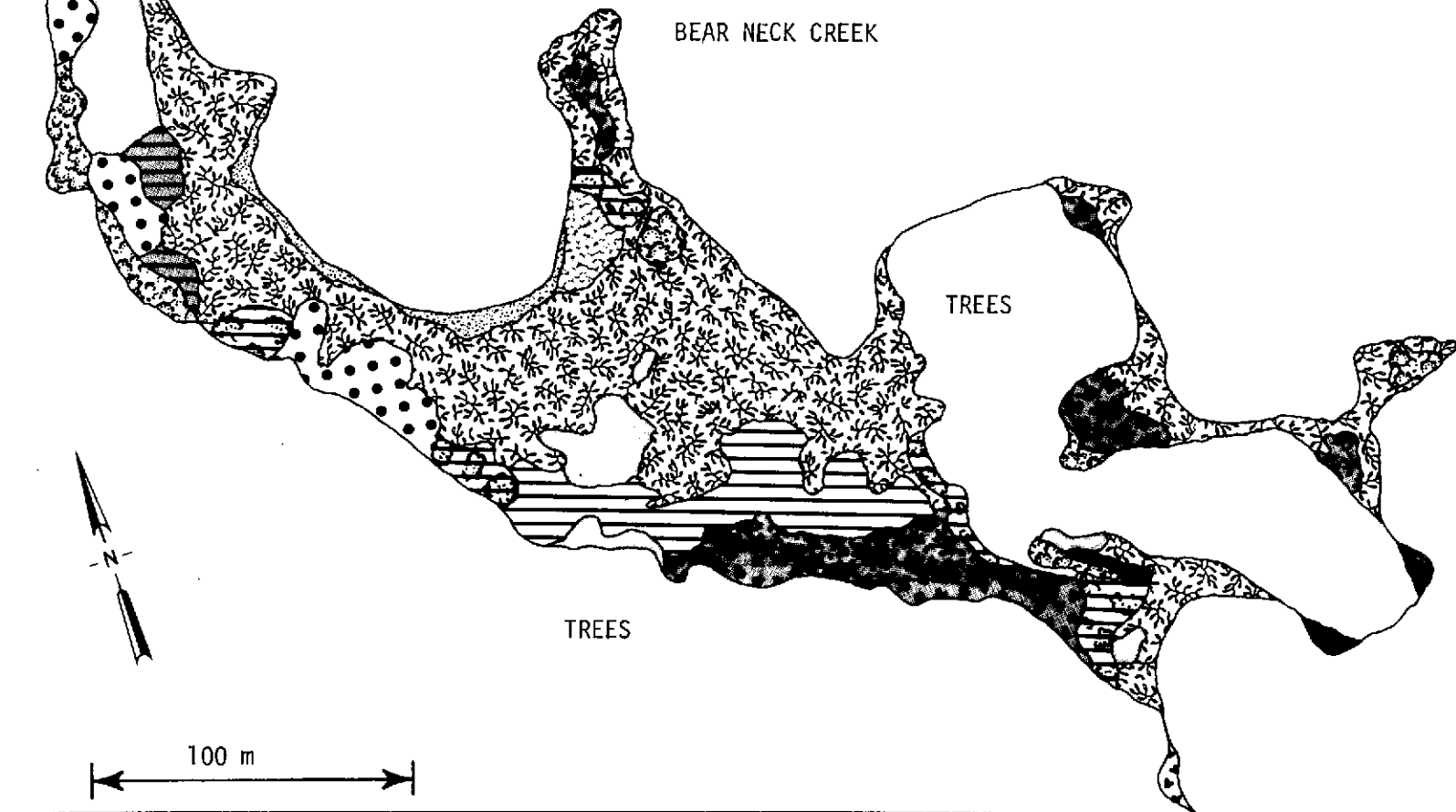
100 m

FIGURE 17

FIGURE 18

BEAR NECK CREEK MARSH - EARLY SUMMER KEY

Spartina alterniflora 80 - 100%

Distichlis spicata/Spartina patens 60 - 100%

Scirpus Olneyi 40 - 80%

Scirpus Olneyi 40%, Distichlis spicata/Spartina patens 60%

Iva frutescens 80 - 100%

Iva frutescens 40%, Distichlis spicata/Spartina patens 40%, Solidago sempervirens 20%

Scirpus Olneyi 40 - 50%, Iva frutescens 20 - 30%, Distichlis spicata/ Spartina patens 20 - 40%

Distichlis spicata/Spartina patens 60 - 70%, Hibiscus palustris 20 - 30%, Panicum virgatum 10%

Hibiscus palustris 80 - 100%

Phragmites communis 100%

Typha angustifolia 90 - 100%

Mud/ shallow water

Shrubs and small trees

BEAR NECK CREEK MARSH
LATE SUMMER ASPECT

BEAR NECK CREEK

TREES

TREES

N

100 m

FIGURE 19

FIGURE 20

BEAR NECK CREEK MARSH - LATE SUMMER KEY

Iva frutescens 80 - 100%

Iva frutescens 40%, Distichlis spicata/Spartina patens 40%, Solidago sempervirens 20%

Distichlis spicata/Spartina patens 60 - 100%

Distichlis spicata/Spartina patens 60 - 70%, Hibiscus palustris 20 - 30%, Panicum virgatum 10%

Hibiscus palustris 80 - 100%

Scirpus Olneyi 40 - 80%

Distichlis spicata/Spartina patens 60%, Scirpus Olneyi 40%

Scirpus Olneyi 40 - 50%, Iva frutescens 20 - 30%, Distichlis spicata/Spartina patens 20 - 40%

Typha angustifolia 90 - 100%

Spartina alterniflora 80 - 100%

Phragmites communis 100%

Shrubs and small trees

Mud/shallow water

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FIGURE 21

TRIBUTARY MARSHES OF BEAR NECK CREEK - LATE SUMMER ASPECT
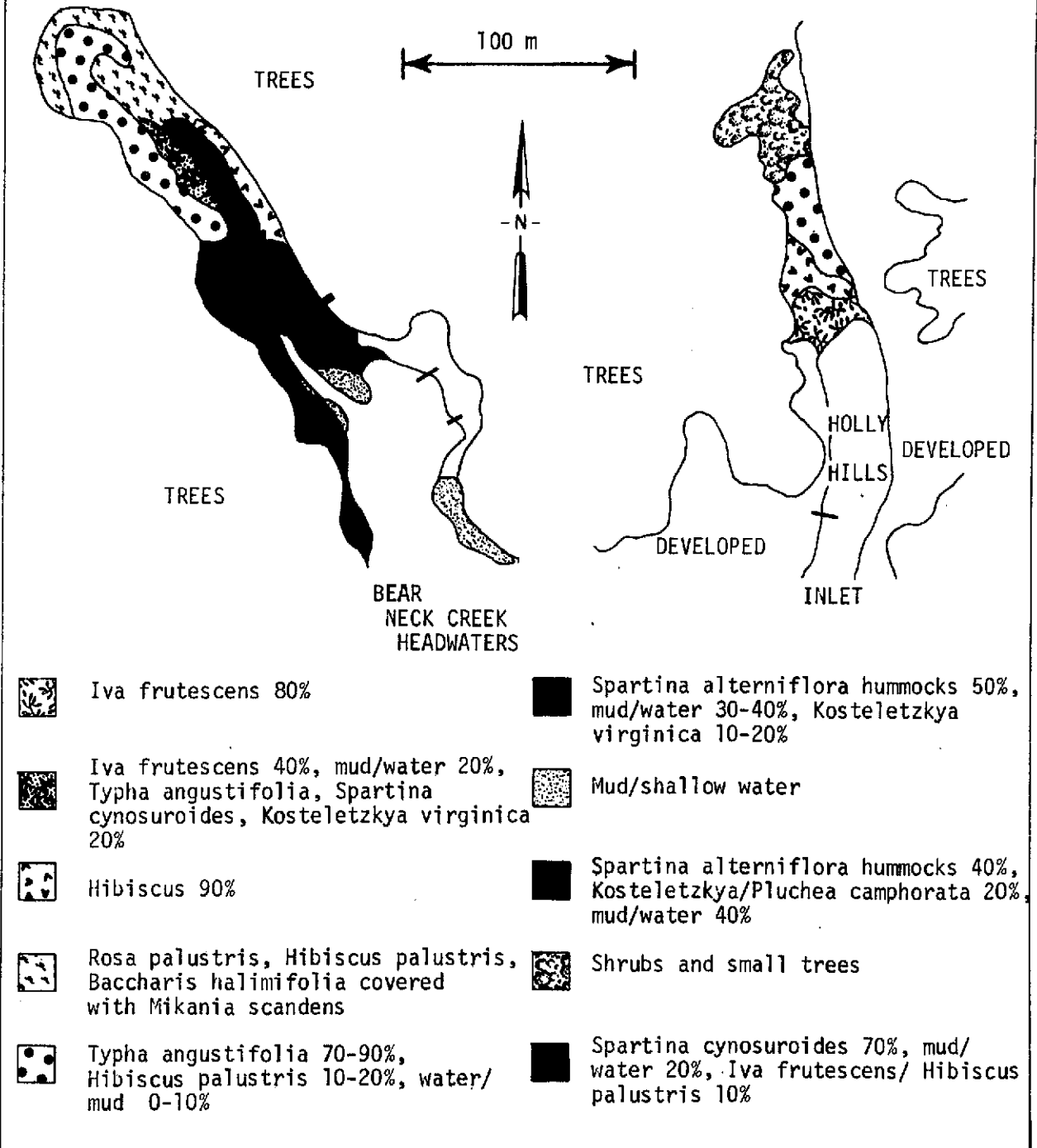
FIGURE 22

CHESTON POINT MARSH
EARLY SUMMER ASPECT

RHODE RIVER

TREES

CHESTON
CREEK

-N-

100 m
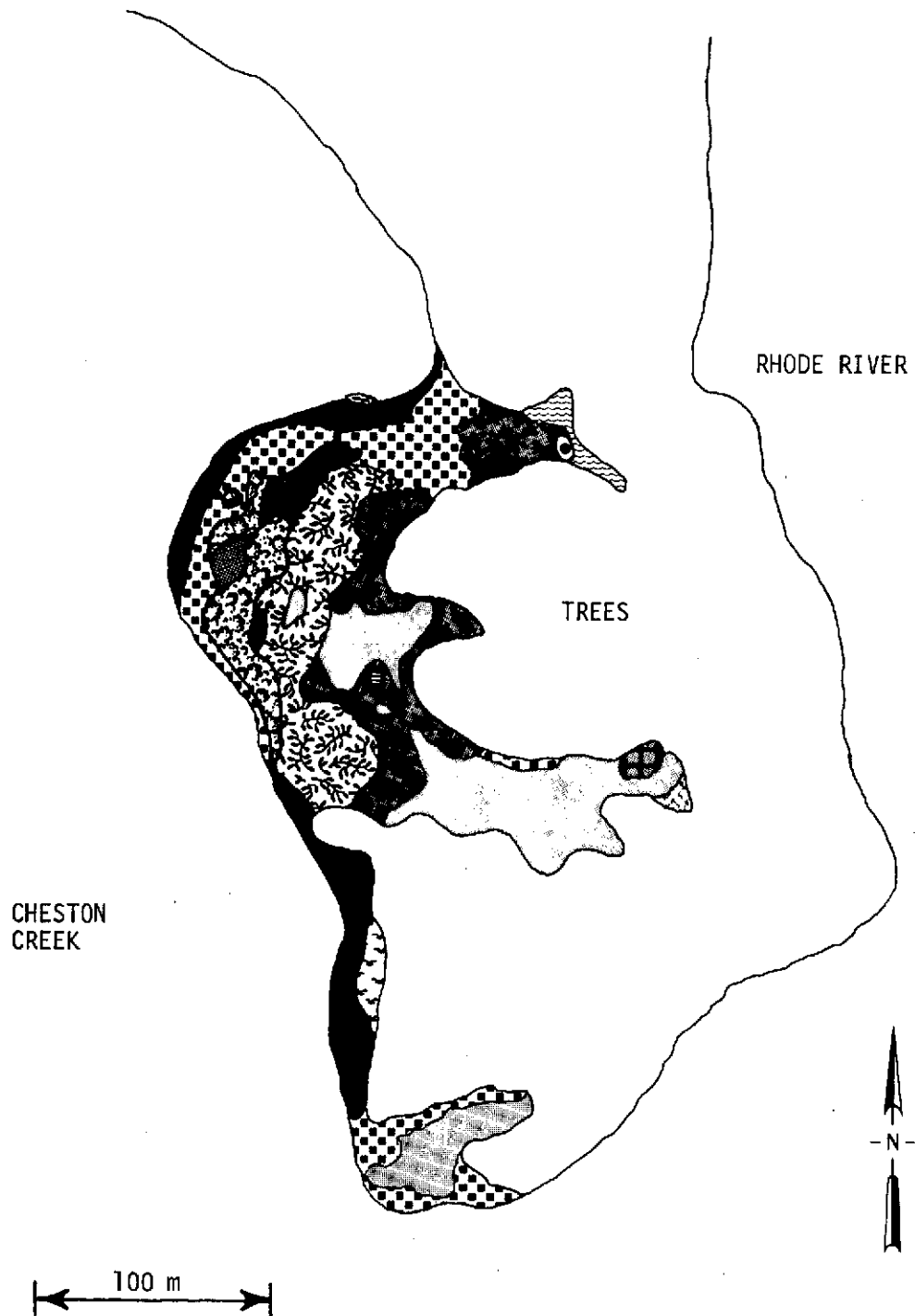
FIGURE 23

CHESTON POINT MARSH - EARLY SUMMER KEY

Typha angustifolia 80-100%

Typha angustifolia 50%, Distichlis spicata/Spartina patens 50%

Typha angustifolia 60%, Iva frutescens 20%, Distichlis spicata/
Spartina patens 20%

Distichlis spicata/Spartina patens 70-100%

Distichlis spicata/Spartina patens 60-80%, Iva frutescens 20-40%

Iva frutescens 60-90%, Distichlis spicata/Spartina patens 10-40%

Panicum virgatum 80-100%

Iva frutescens/Baccharis halimifolia 30%, Panicum virgatum 50%,
Hibiscus palustris, Solidago sempervirens, and Spartina patens 20%

Iva frutescens/Baccharis halimifolia 70-100%

Phragmites communis 100%

Spartina alterniflora 80-100%

Scirpus Olneyi 100%

Scirpus robustus 50%, Distichlis spicata/Spartina patens 50%

Shrubs, small trees

FIGURE 24

CHESTON POINT MARSH
LATE SUMMER ASPECT

RHODE RIVER

TREES

CHESTON
CREEK

100 m

-N-
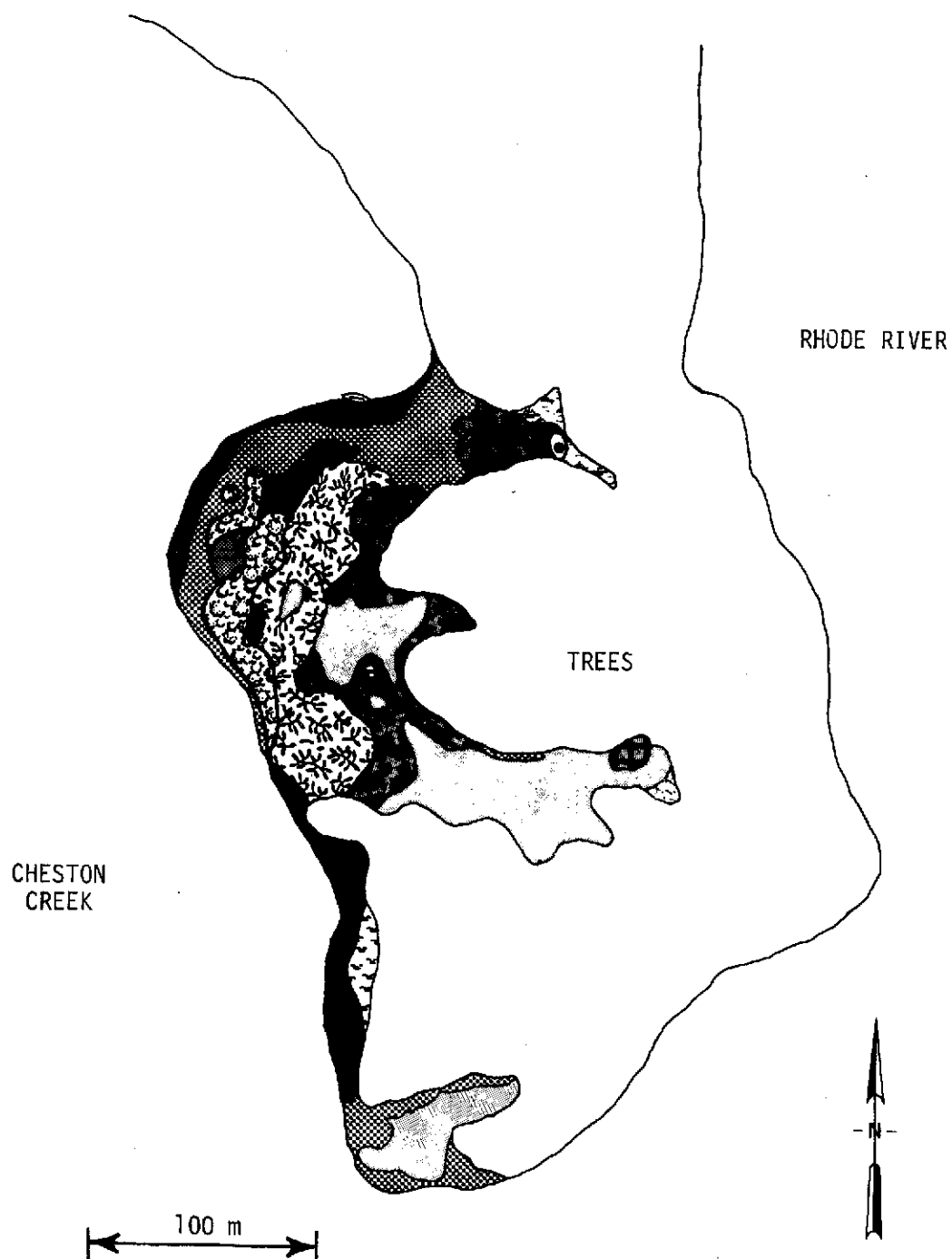
FIGURE 25

CHESTON POINT MARSH - LATE SUMMER KEY

Typha angustifolia 80 - 100%

Typha angustifolia 50%, Distichlis spicata/Spartina patens 50%

Distichlis spicata/Spartina patens 70 - 100%

Distichlis spicata/Spartina patens 60 - 80%, Iva frutescens 20 - 40%

Iva frutescens 60 - 90%, Distichlis spicata/Spartina patens 10 - 40%

Panicum virgatum 80 - 100%

Panicum virgatum 50%, Iva frutescens/Baccharis halimifolia 30%, Solidago sempervirens, Hibiscus palustris, and Spartina patens 20%

Iva frutescens/ Baccharis halimifolia 70 - 100%

Phragmites communis 80 - 100%

Spartina alterniflora 80 - 100%

Scirpus olneyi 80 - 100%

Scirpus robustus 50%, Distichlis spicata/Spartina patens 50%

Shrubs, small trees

Mixed fall flowers, tall marsh grasses, mud

SELLMAN CREEK MARSH
EARLY SUMMER

100 m

SELLMAN CREEK

TREES

TREES

TREES

TREES

-N-
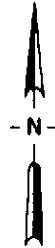
Mud/shallow water

Spartina alterniflora 50-80%

Spartina alterniflora 80-100%

Distichlis spicata/
Spartina patens 60-100%

Iva frutescens 80-100%

Iva frutescens 20-40%
Distichlis spicata/
Spartina patens 60-80%

Iva frutescens 40-50%
Shrubs and small trees 40-50%

Scirpus Olneyi 50-80%

Typha angustifolia 60-100%

Hibiscus palustris 50%
Typha angustifolia 50%

Fresh water marsh: grasses,
mints, arrowhead, shrubs

Shrubs and dead trees

FIGURE 26

SELLMAN CREEK MARSH
LATE SUMMER

100 m

SELLMAN CREEK

TREES

TREES

TREES

TREES

- N -

FIGURE 27

47

Typha angustifolia
60-100%

Hibiscus palustris 50%
Typha angustifolia 50%

Distichlis spicata/
Spartina patens 60-100%

Scirpus robustus 80%

·Mud/shallow water

Spartina alterniflora 50-80%

Iva frutescens 20-40%,
Distichlis spicata/Spartina
patens 60-80%

Fresh water marsh:grasses,
mints, arrowheads, shrubs

Spartina alterniflora 60%
Acnida cannabina 30%

Iva frutescens 80-100%

Polygonum hydropiperoides 80%

Iva frutescens 40-50%
Shrubs and small trees 40-50%

Scirpus Olneyi 50-80%

Shrubs and dead trees covered
by Mikania scandens

FIGURE 28

FOX CREEK MARSH - ALL SUMMER

Scirpus Olneyi 70-80%, Distichlis spicata 20-30%

Scirpus Olneyi 50%, Distichlis spicata 50%

Iva frutescens 60-70%, Spartina alterniflora 30-40%

Typha angustifolia 100%

Iva frutescens 60-90%, Spartina patens/ Distichlis spicata 10-40%

Iva frutescens 90-100%, Spartina patens 0-10%

Spartina patens 80-90%, Iva frutescens 10-20%

Spartina cynosuroides 100%

TREES

FOX CREEK

TREES

TREES

- N -

100 m
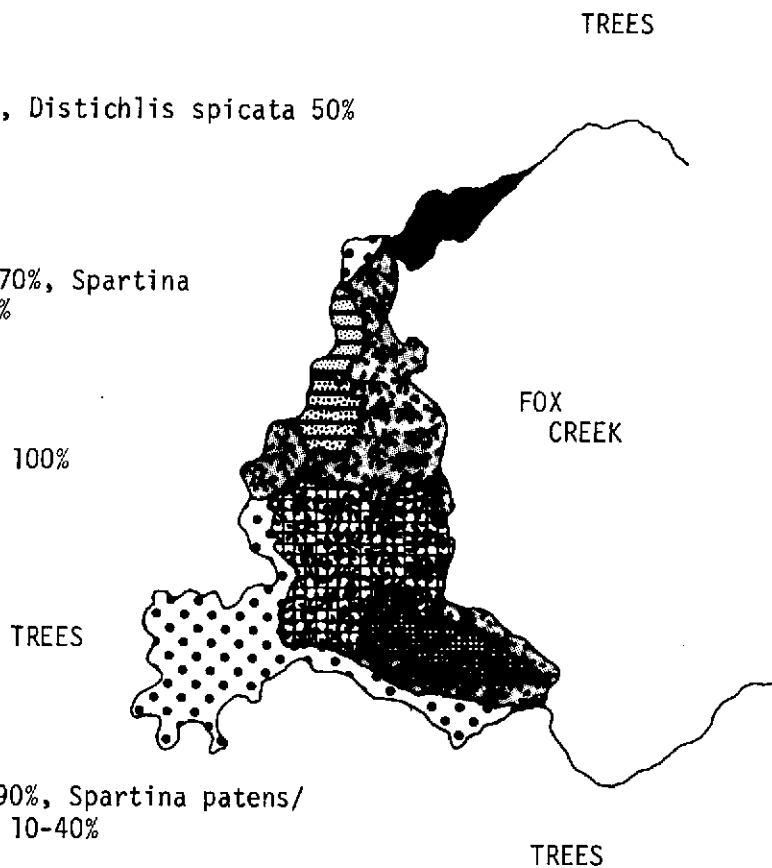
SEASONAL VARIATION IN PHRAGMITES COMMUNIS - A SPECIAL CASE

Patches of Phragmites communis are easily seen both on the ground and in aerial photographs; the plant grows in pure stands and retains the flowering head on dead stems through winter and spring until new growth replaces it in mid to late summer. On natural color aerial transparencies, Phragmites patches look the same; gray or blue-gray with a smooth, thick texture. On aerial photos taken in late summer, however, the largest patch of Phragmites in Rhode River, that on Kirkpatrick Marsh, appears brown. The small patches of Phragmites on Hog Island, Bear Neck Creek, and even Kirkpatrick Marsh appear typically gray or blue-gray. Flights 32 (11/8/70) and 89 (10/7/71) both show this difference. The appearance of Phragmites on different films is given below.

Flight	Date	Film Type	Large Patch in Kirkpatrick	Small Patches
15	6/30/70	Nat. Color	Blue-gray	Blue-gray
32	11/8/70	Nat. Color	Light brown	Gray
73	7/13/71	Nat. Color	Blue-gray	Blue-gray
89	10/7/71	Nat. Color	Dark brown	Gray
113	6/7/72	Nat. Color	Blue-green-gray	Blue-gray

The individual Phragmites plants making up the large patch are markedly less robust than those in the smaller patches. The later are 2.5 to 3 meters tall with flowering heads of 33 x 15 cm while the plants in the large patch are 1.5 to 1.8 meters tall with flowering heads of 13 x 5 cm. It would seem that such a striking difference in vigor would result in color differences on aerial photos throughout the year. At this time, the cause of the lessened vigor in the large Phragmites patch in Kirkpatrick marsh is unknown.

The fact that such changes can occur seasonally with vegetation types thought to be readily identifiable indicates that seasonal monitoring is essential for accurate photointerpretation.

ANALYSIS OF COVER IN THREE MARSH VEGETATION TYPES

The seasonal variability of marsh vegetation has necessitated the accurate determination of marsh composition and cover patterns. To date, this determination has been made for three major vegetation types or communities in Hog Island Marsh: those dominated by Iva frutescens, Distichlis spicata/ Spartina patens, and Typha angustifolia. These communities were chosen for their size and ease of recognition on natural color aerial transparencies. Their boundaries had previously been mapped. Hog Island Marsh was chosen as a site because of its accessability, the presence of a 100 m grid system and its recent use for productivity studies.

The three communities were divided into sections of approximately 20 m^2 each. Three sampling sites were chosen in each section, using a random numbers table. This method produced a fairly even "stratified" coverage of each community while still allowing statistical testing of the data. The sampling sites were marked on a 10 m^2 grid superimposed over an aerial transparency (Fig.12). Percentage of cover for each plant species and for exposed mud or water was estimated at each site with a 1 X 2 m sampling frame. The cover of the deciduous Iva frutescens was estimated as if all the leaves were present.

Figures 29 - 42 show the composition and percentages of cover in each sample plot. Table 3 shows the mean percentage of cover, standard deviation, and standard error of the mean for all species in each community.

As indicated by the standard deviation in Table 3, the Typha community is least heterogeneous with respect to cover variation within the community. The Distichlis/Spartina community is intermediate, with the Iva community most heterogeneous. The denseness of the Distichlis/Spartina community is reflected in the high percentage of area covered by the type species association (70 percent) while exposed mud and water accounted for only 8 percent.

The _Iva frutescens_ community is by far the most heterogeneous as to species composition, although many of the associated species account for little cover. Cover variation within the community is also very high; this is evidenced by the high standard deviation in species with most cover: _Iva frutescens_, _Distichlis spicata/Spartina patens_, and _Scirpus Olneyi_.

As shown in Figures 29 - 42, the eastern and western stands of the _Iva_ community in Hog Island marsh differ markedly in the percent cover of the type species: the eastern stand has a mean _Iva_ cover of 33 percent while the western stand has a mean _Iva_ cover of 16 percent. The latter case is interesting in that it can still be recognized as an _Iva_ community with such a low percent cover of the type species. The highest percent cover is contributed by mud and shallow water. The significant area of marsh covered by mud and water, especially in the _Iva_ community, demonstrates that texture and color seen on aerial photographs may be due as much to the spaces between plants as to the plants themselves.

TABLE 3

MEANS, STANDARD DEVIATIONS, AND STANDARD ERRORS OF COVER SAMPLES

Vegetation Type	n Sample Number	Species Present	Mean Cover (% 2-m^2 plot)	S.D. Standard Deviation	S.E. Standard Error of the Mean
Typha	10	Typha angustifolia	56	8	3
		Polygonum hydropiperoides	2	3	1
		Spartina alterniflora	1	2	0.7
		Hibiscus palustris	1	2	0.7
		Iva frutescens	2	6	2
		Scirpus Olneyi	5	10	3
		Mud/water	29	11	4
Distichlis spicata/ Spartina patens	15	Distichlis spicata/ Spartina patens	70	21	5
		Scirpus Olneyi	17	14	4
		Acnida cannabina	0.3	0.7	0.2
		Solidago sempervirens	1	1.5	0.4
		Polygonum hydropiperoides	1	1	0.4
		Mud/water	8	10	2.5
Iva frutescens	27	Iva frutescens	25	18	3
		Distichlis spicata/ Spartina patens	15	20	4
		Scirpus Olneyi	14	14	3
		Polygonum hydropiperoides	2	5	0.9
		Spartina cynosuroides	8	13	3
		Spartina alterniflora	4	7	1
		Solidago sempervirens	0.07	0.4	0.1
		Hibiscus palustris	0.6	2	0.4

TABLE 3 (Continued)

Vegetation Type	n Sample Number	Species Present	Mean Cover (% 2-m^2 plot)	S.D. Standard Deviation	S.E. Standard Error of the Mean
Iva frutescens	27	Pluchea camphorata	1	4	0.7
		Kosteletzkya virginica	0.6	2	0.3
		Baccharis halimifolia	0.4	2	0.4
		Juncus spp.	0.4	1	0.3
		Panicum virgatum	4	9	2
		Mud/water	25	17	3
Iva frutescens (Eastern plots)	15	Iva frutescens	33	20	5
		Distichlis spicata/ Spartina patens	20	22	6
		Scirpus Olneyi	8	11	3
		Polygonum hydropiperoides	2	4	1
		Spartina cynosuroides	5	11	3
		Spartina alterniflora	6	9	2
		Hibiscus palustris	0.3	1	0.3
		Pluchea camphorata	0.9	3	0.7
		Panicum virgatum	6	11	3
		Mud/water	24	19	5
Iva frutescens (Western plots)	12	Iva frutescens	16	9	3
		Distichlis spicata/ Spartina patens	9	16	5
		Scirpus Olneyi	23	12	4
		Polygonum hydropiperoides	3	6	2

TABLE 3 (Continued)

Vegetation Type	n Sample Number	Species Present	Mean Cover ($\%$ 2-m^2 plot)	S.D. Standard Deviation	S.E. Standard Error of the Mean
Iva frutescens (Western plots)	12	Spartina cynosuroides	13	14	4
		Spartina alterniflora	3	5	1
		Solidago sempervirens	0.2	0.6	0.2
		Hibiscus palustris	0.8	3	0.8
		Pluchea camphorata	2	4	1
		Kosteletzkya virginica	1	2	0.7
		Baccharis halimifolia	1	3	0.8
		Juncus spp.	0.8	2	0.6
		Panicum virgatum	0.8	3	0.8
		Mud/water	27	15	4

Mean Percent Cover: Iva Stands

EAST STAND

```
100
 80
 60
 40
 20
```

33 20 8 2 5 6 0 .3 .9 0 0 0 6   24

Iva Sp/D Scrp Pol Sp cyn Sp alt Sol Hib Plu Kos Bac Junc Pan   Mud

WEST STAND

```
100
 80
 60
 40
 20
```

16 9 23 3 13 3 .2 .8 2 1 1 .8 .8   27

Iva Sp/D Scrp Pol Sp cyn Sp alt Sol Hib Plu Kos Bac June Pan   Mud

BOTH STANDS

```
100
 80
 60
 40
 20
```

25 15 14 2 8 4 .07 .6 1 .6 .4 .4 4   25

Iva Sp/D Scrp. Pol Sp cyn Sp alt Sol Hib Plu Kos Bac Junc Pan   Mud
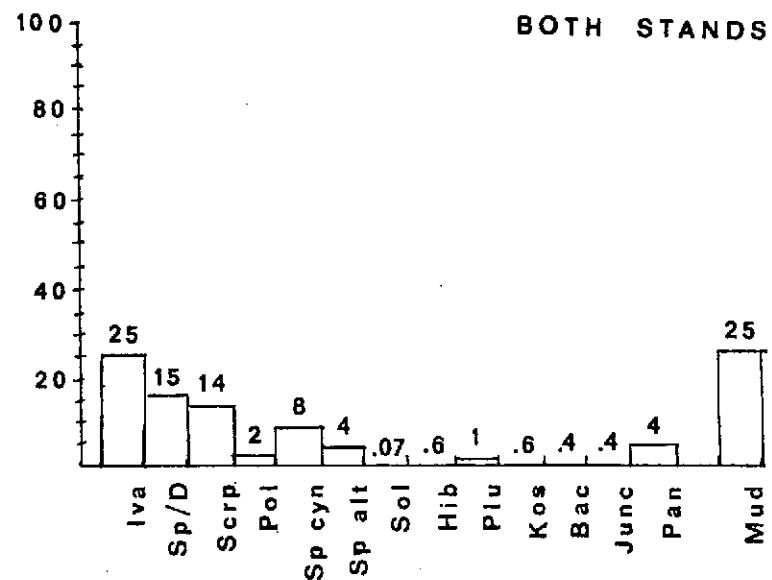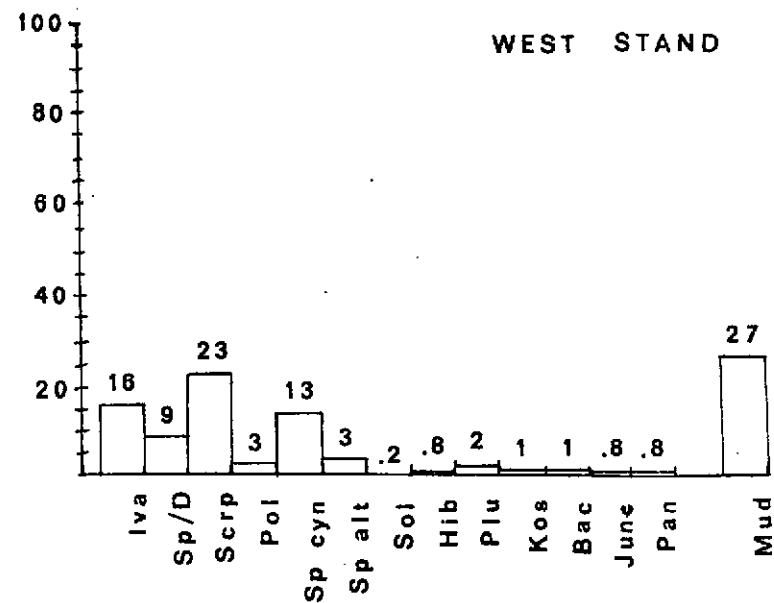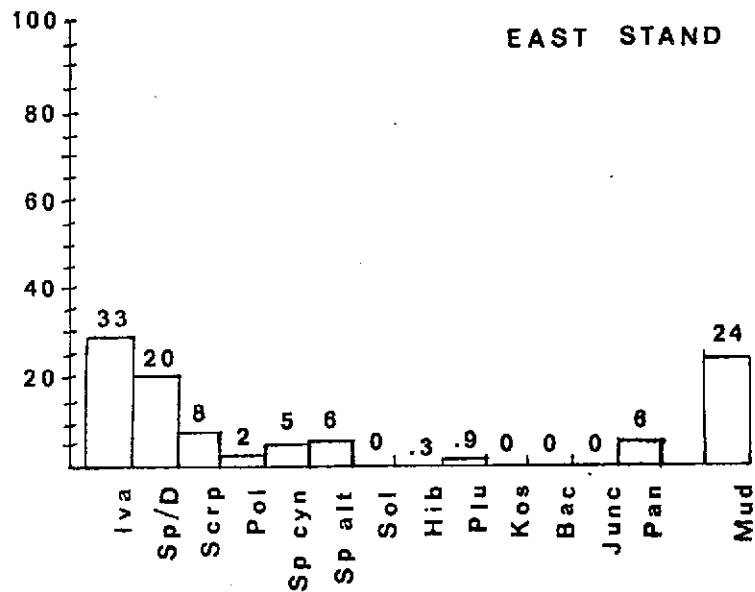
FIGURE 30

Mean Percent Cover

Typha Stand

Spartina/Distichlis Stand

Typha Stand

100	
80	
60	56
40	
20	29

Typha, Pol, Sp alt, Hib, Iva, Scrp, Mud
56, 2, 1, 1, 2, 5, 29

Spartina/Distichlis Stand

|	
100	
80	70
60	
40	
20	17

Sp/D, Scrp, Acn, Sol, Pol, Mud
70, 17, .3, 1, 1, 8
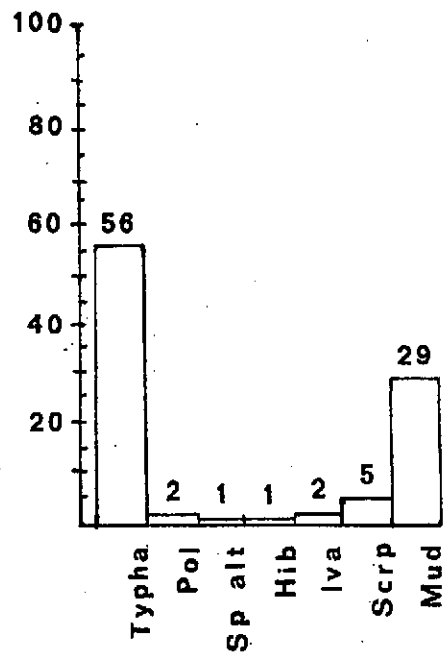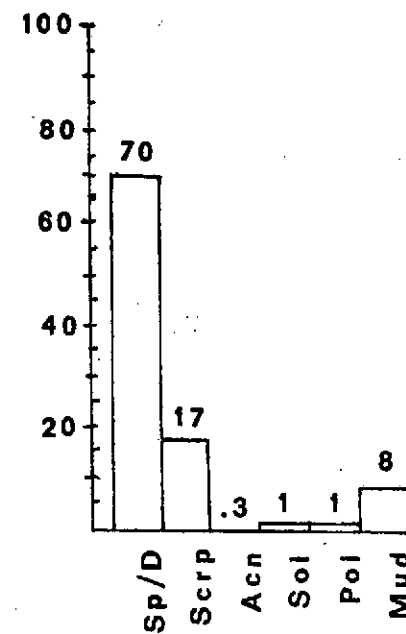
FIGURE 31

Percent Cover: Iva Plots

357185

357197

358147

358166
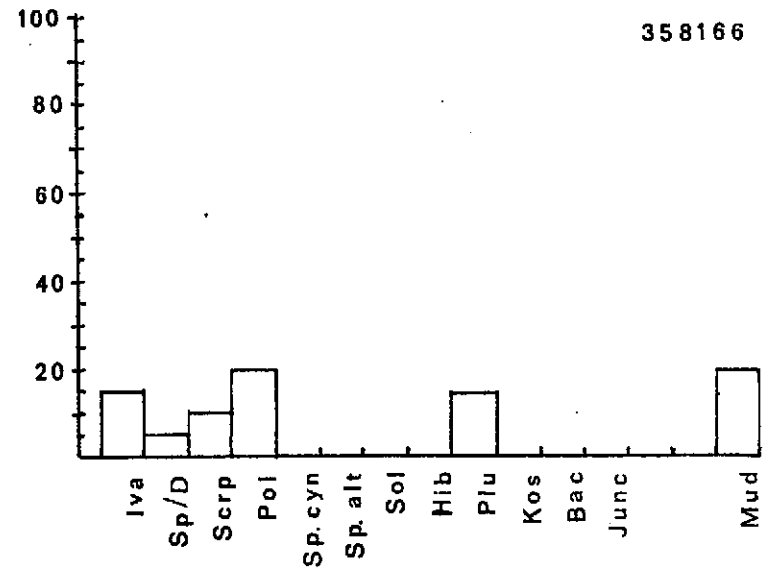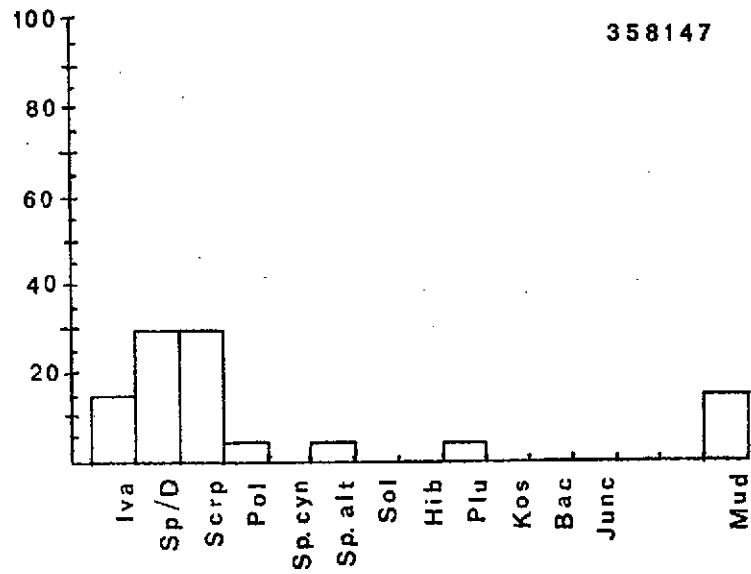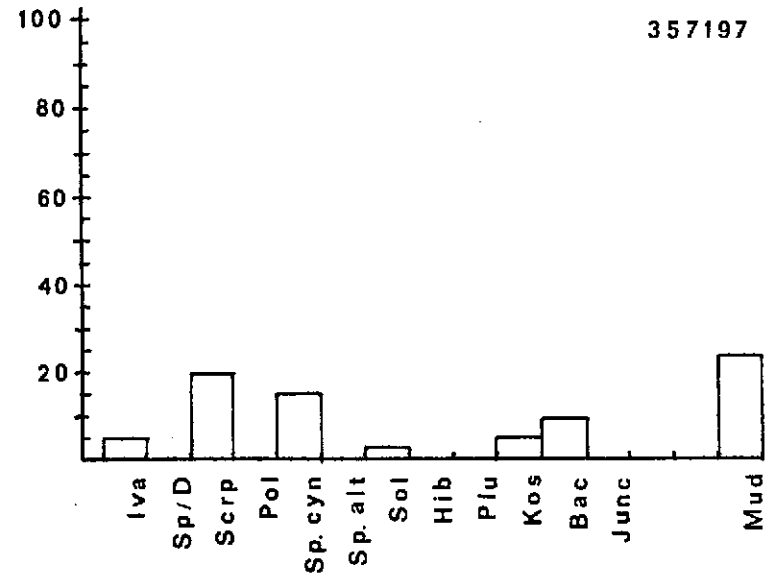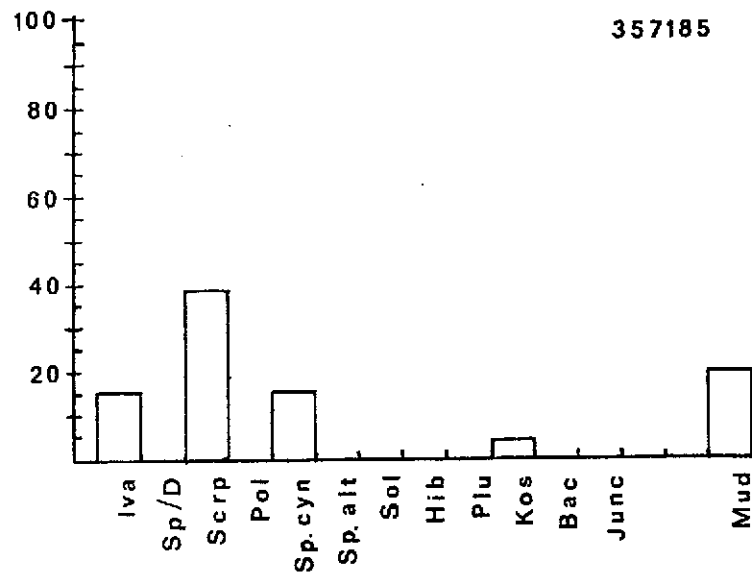
FIGURE 32

Percent Cover: Iva Plots
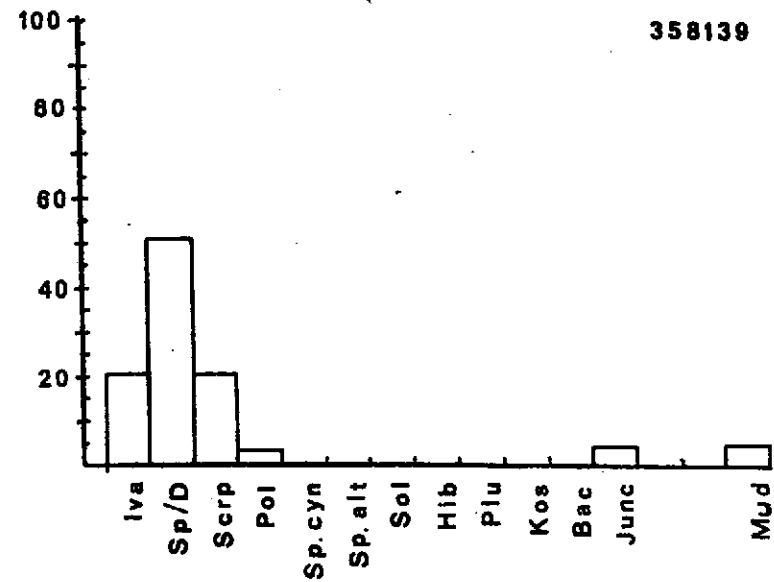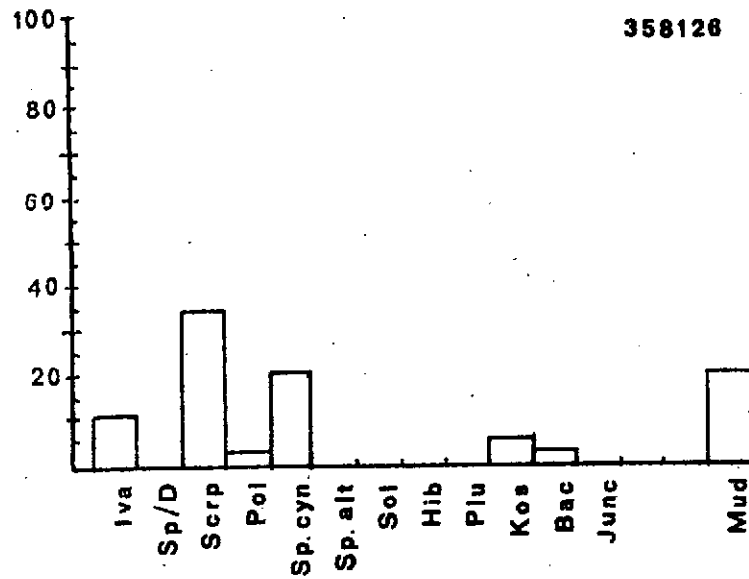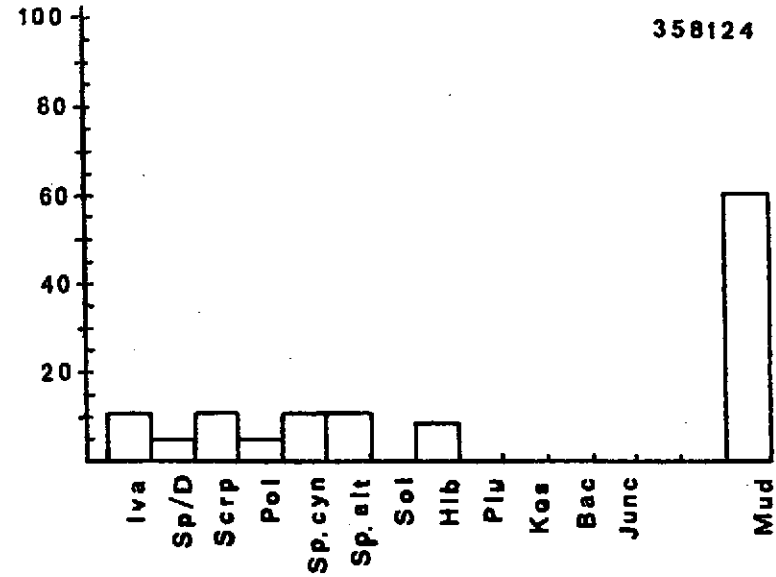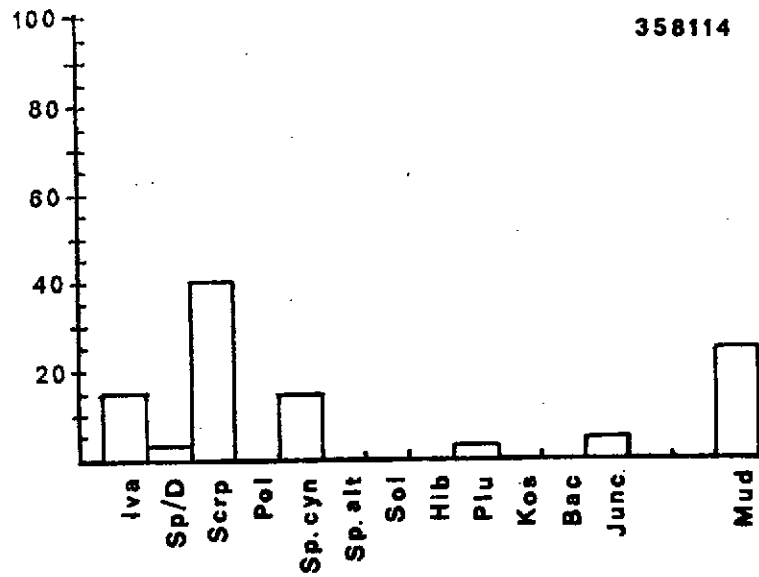
FIGURE 33

Percent Cover: Iva Plots
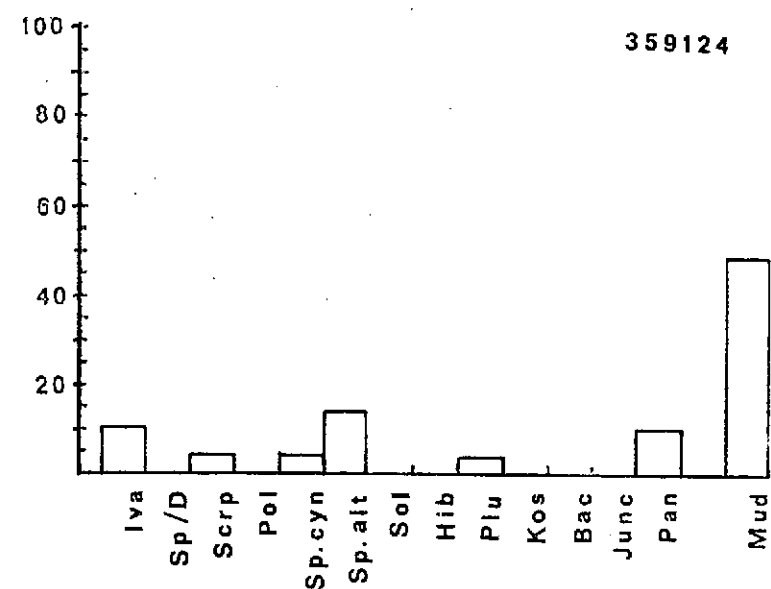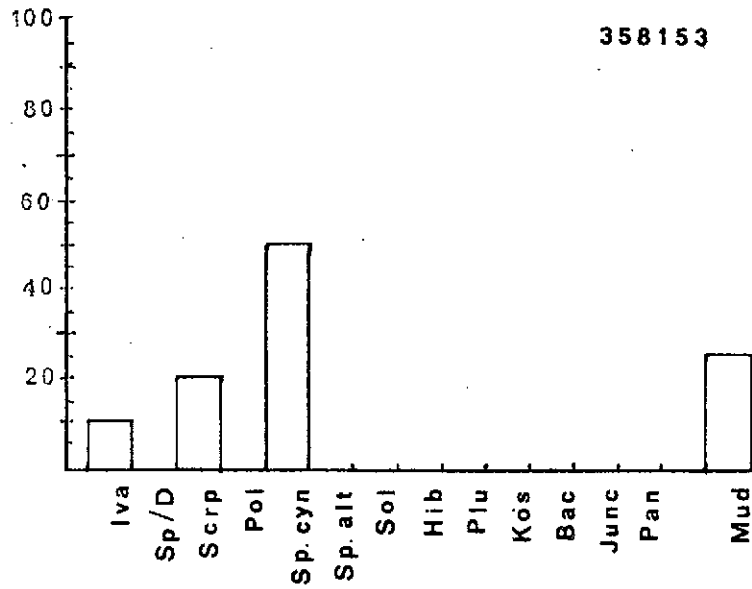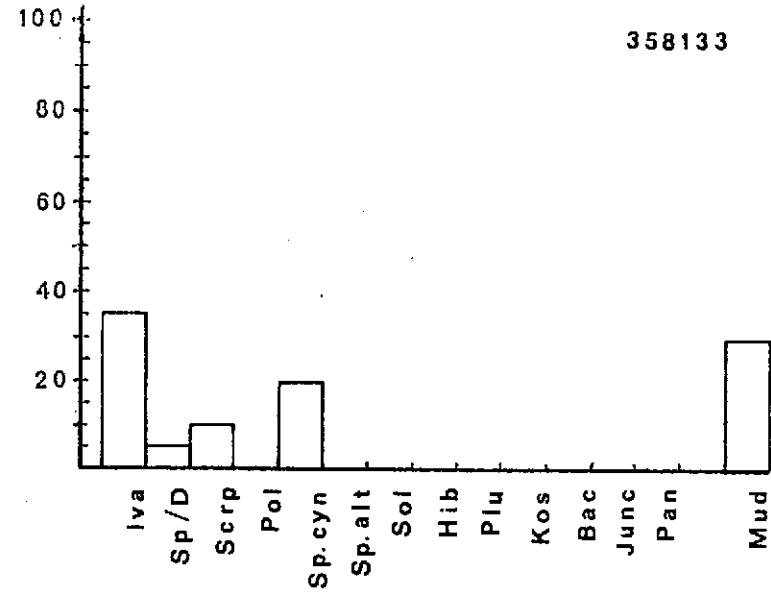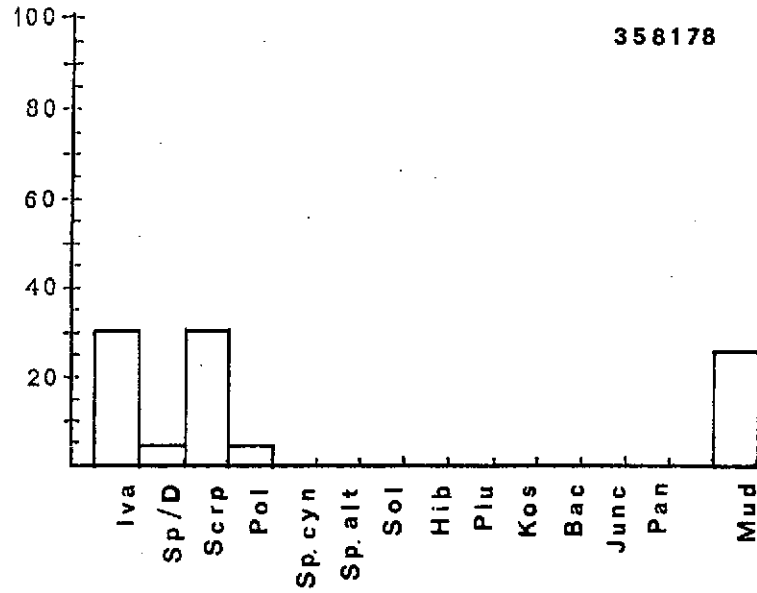
FIGURE 34

Percent Cover: Iva Plots

358306 · 358334 · 358335 · 358358
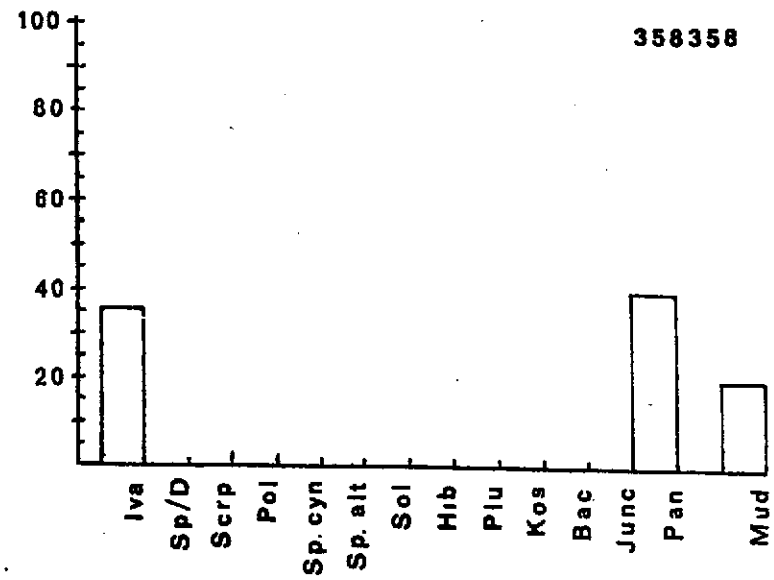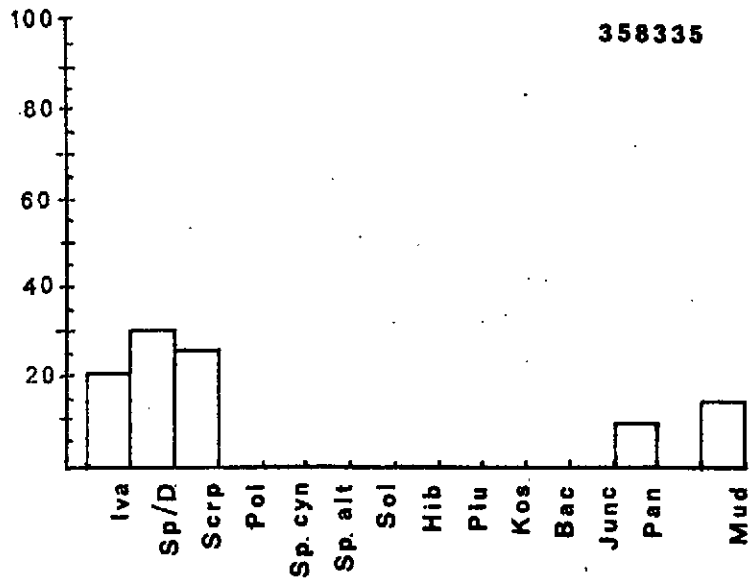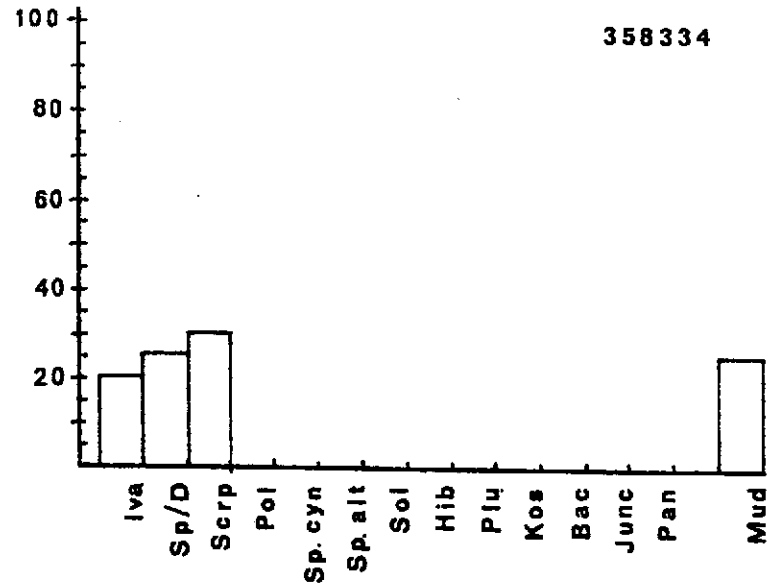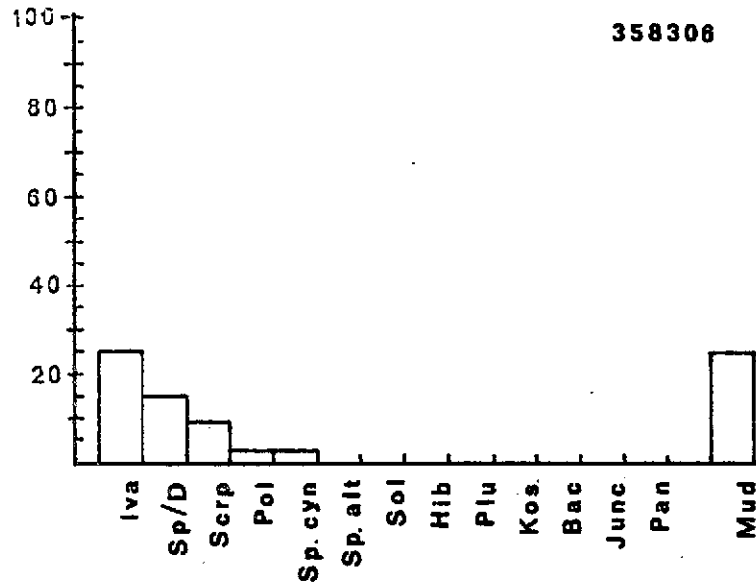
FIGURE 35
Percent Cover: Iva Plots
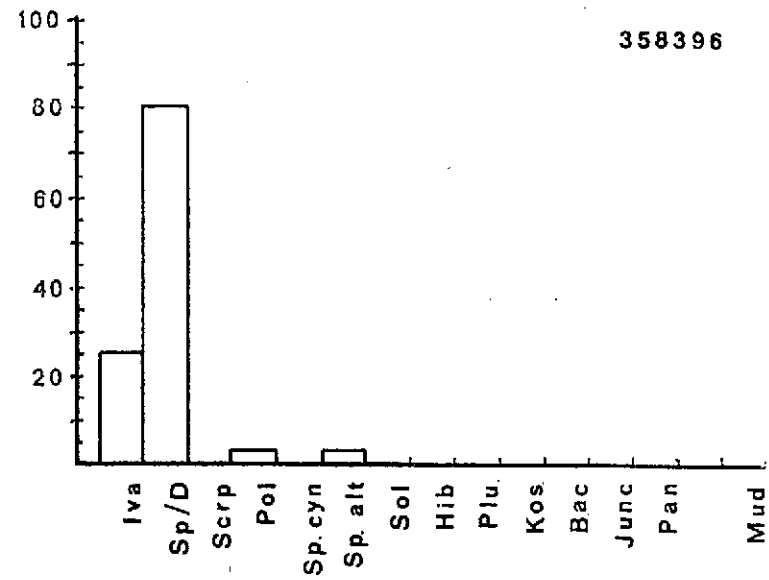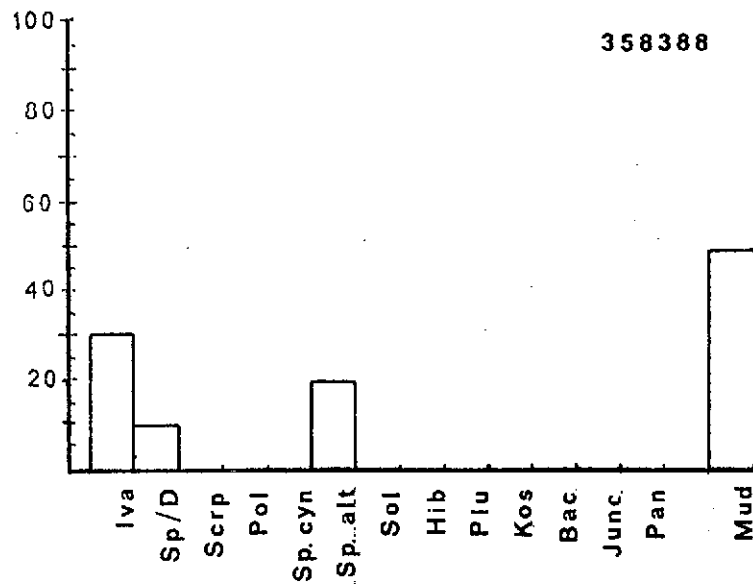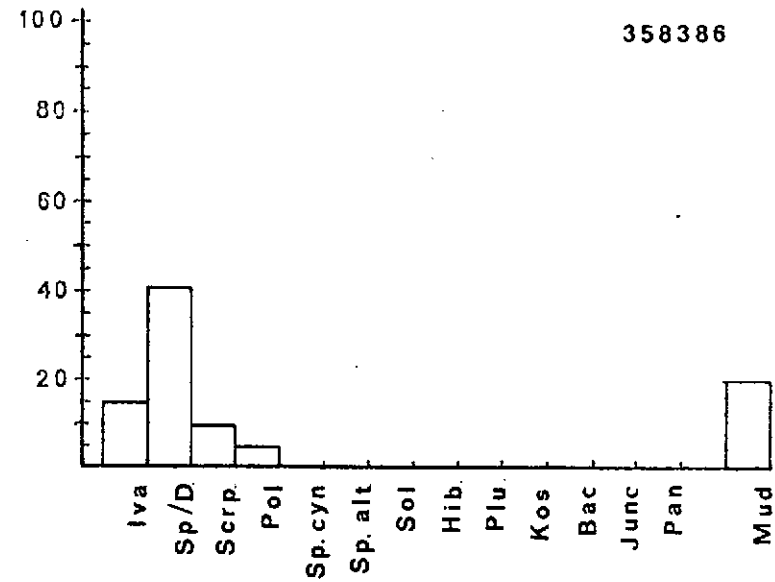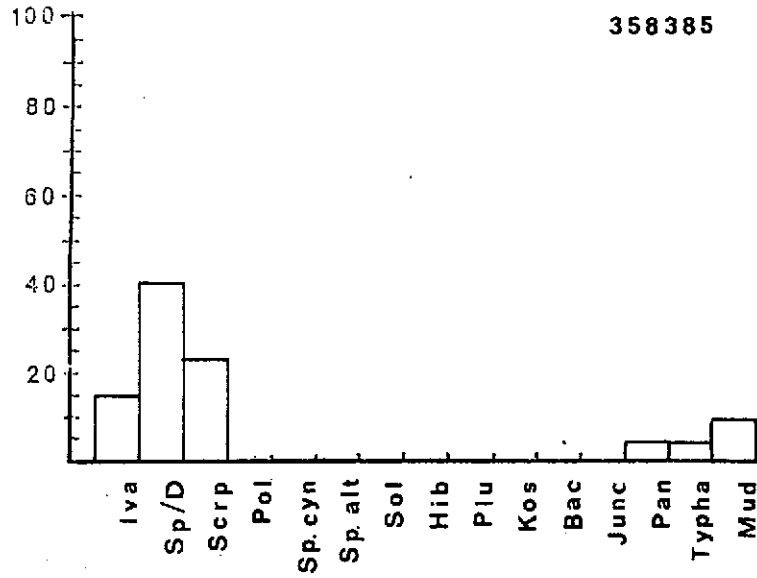
FIGURE 36

Percent Cover: Iva Plots
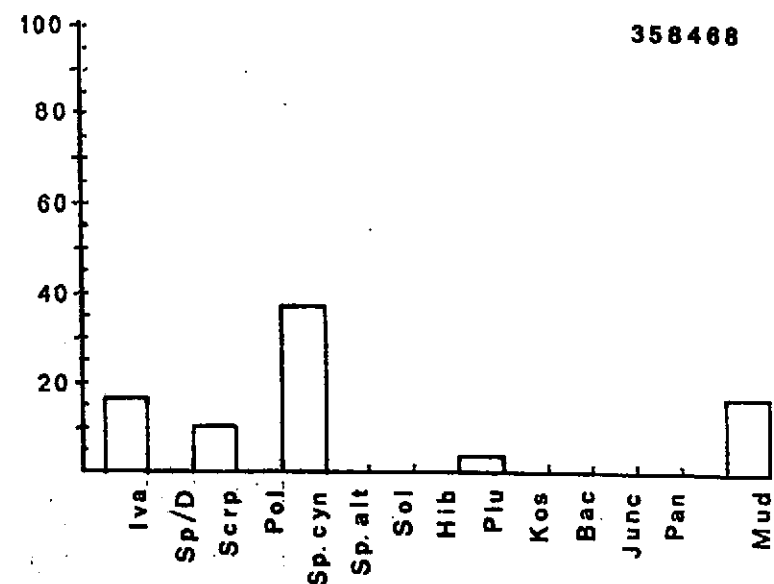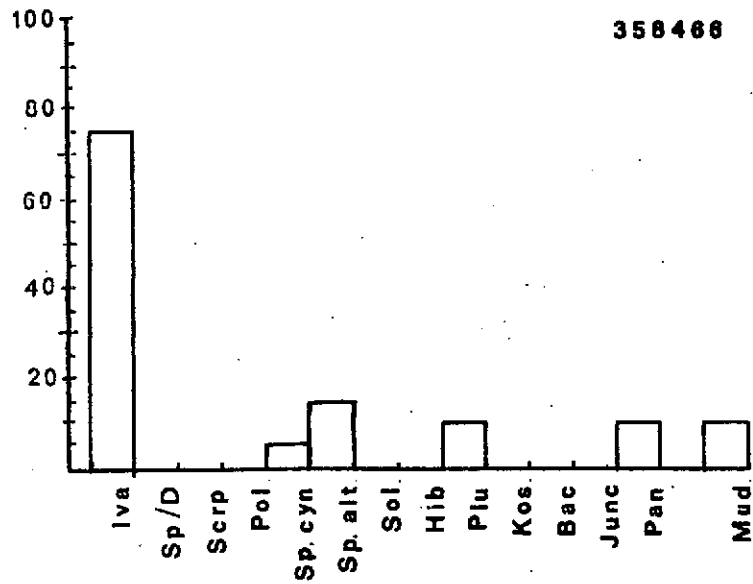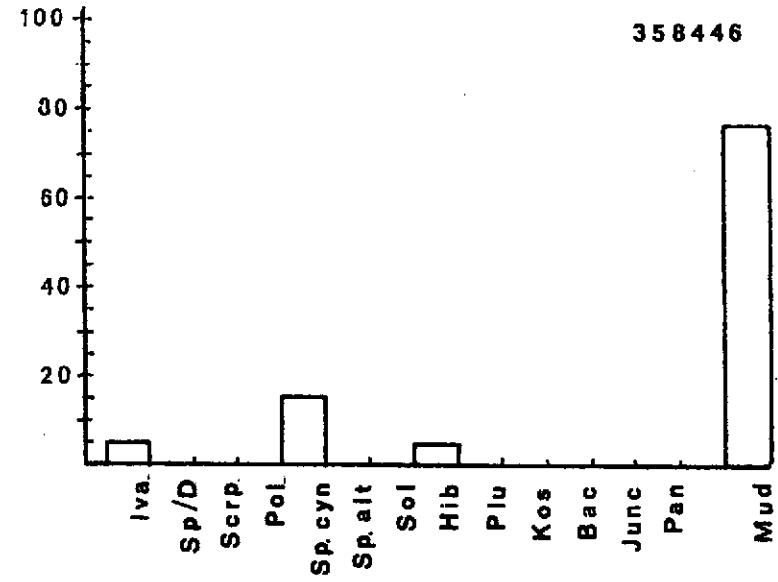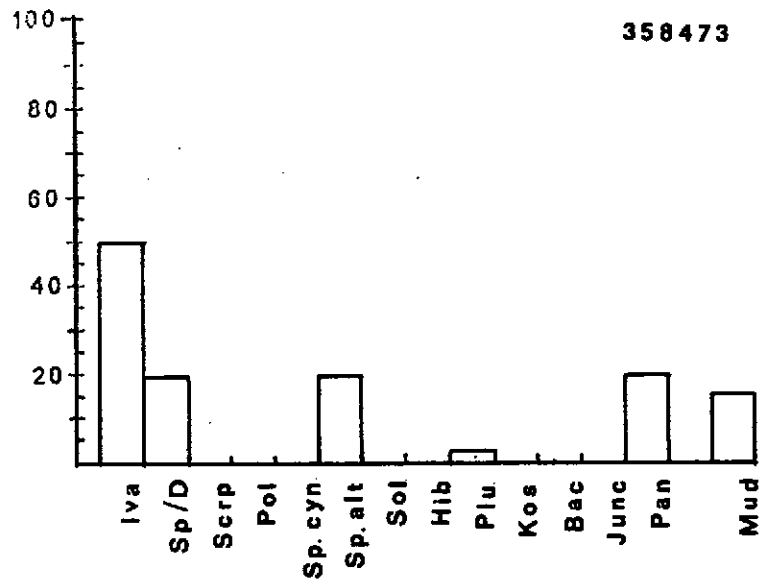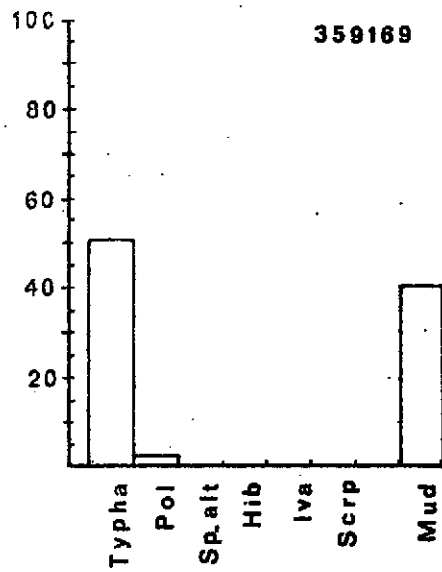
FIGURE 37

Percent Cover: Iva Plots
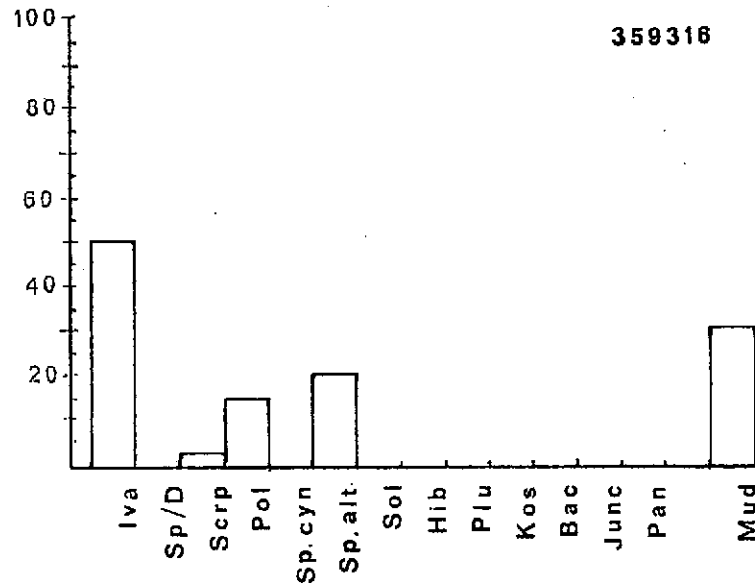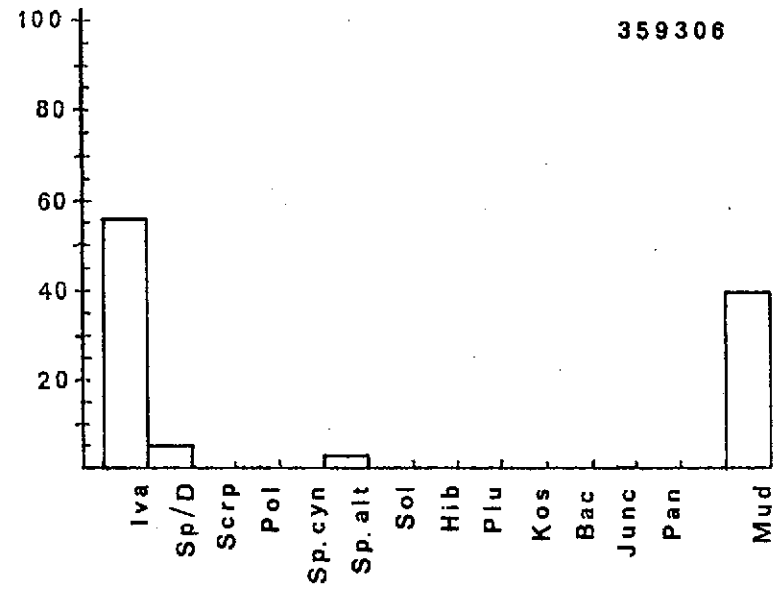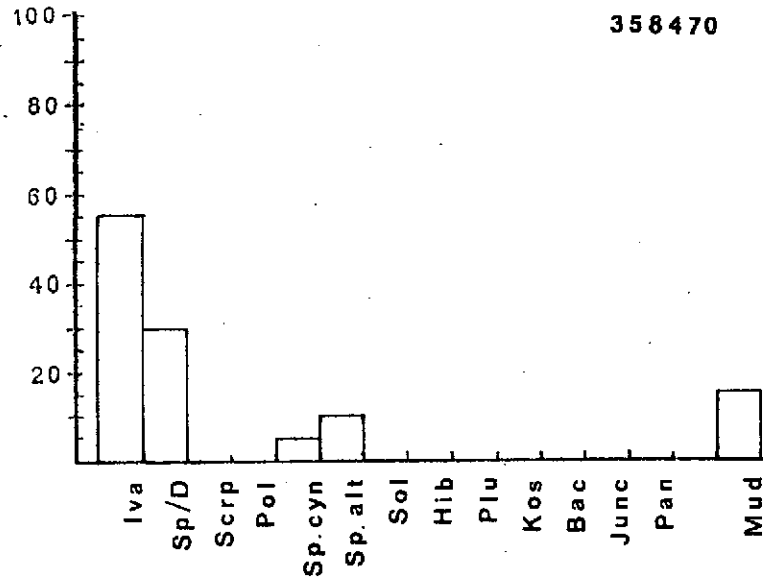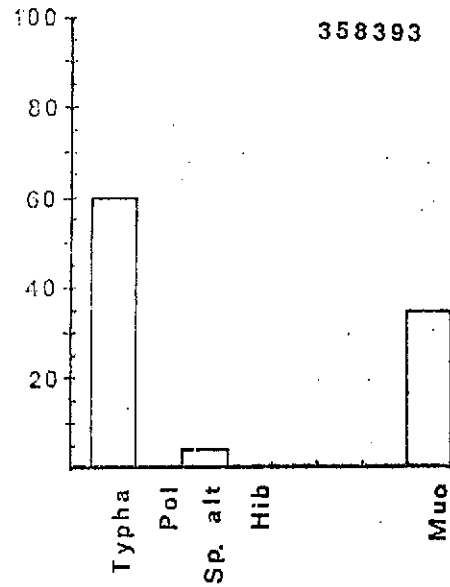
FIGURE 38

Percent Cover: Typha Plots
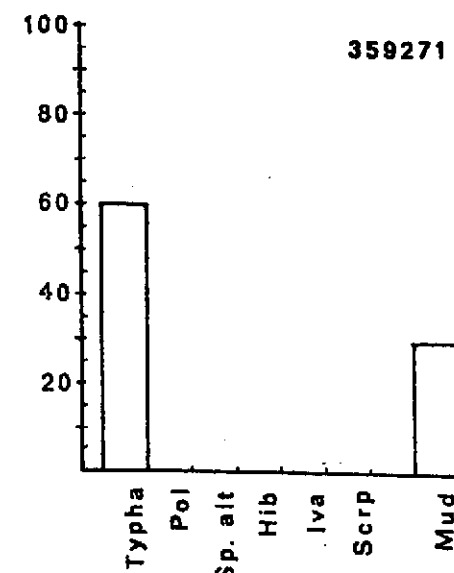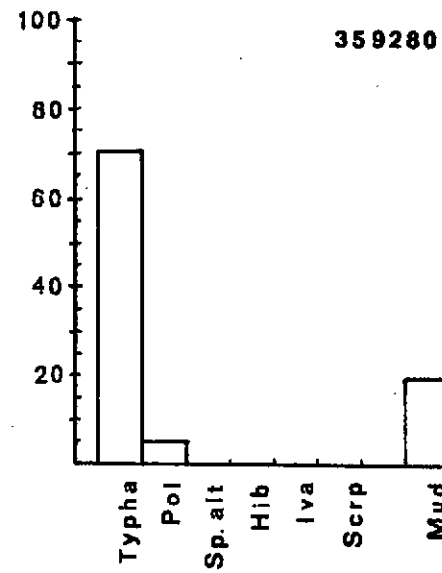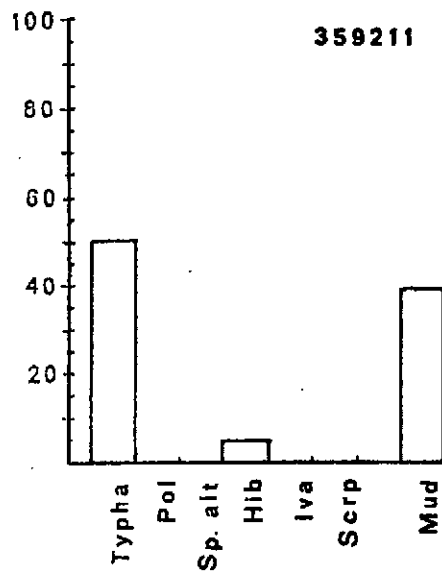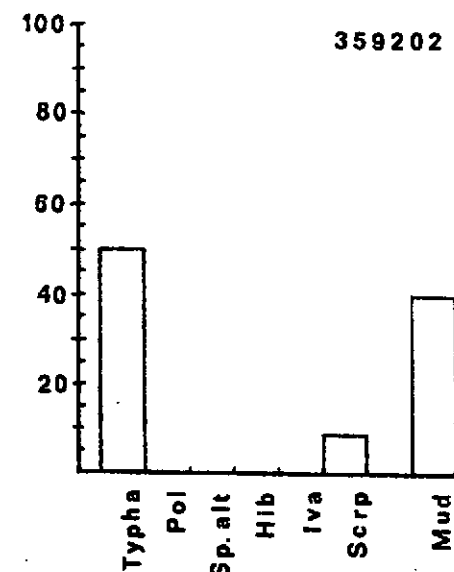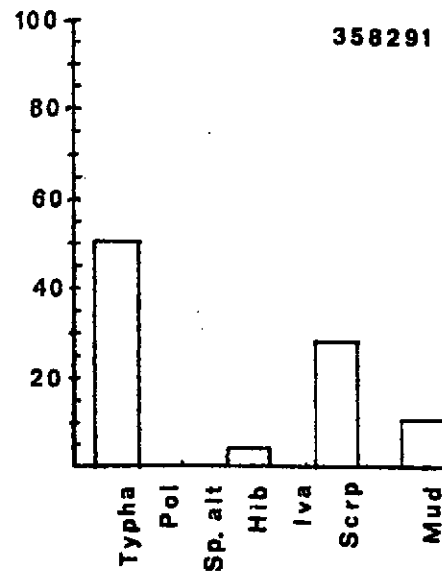
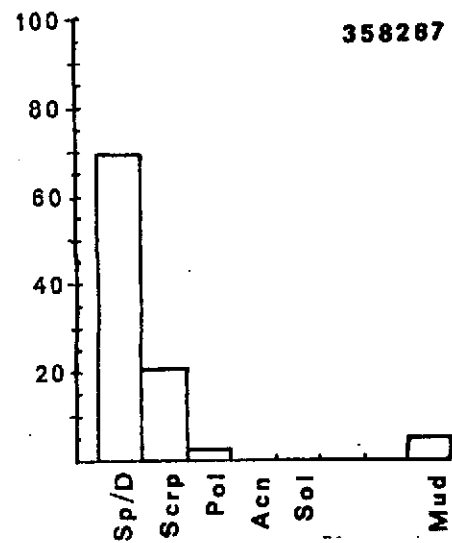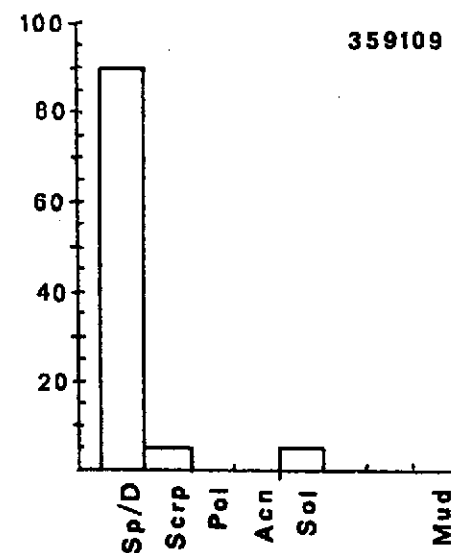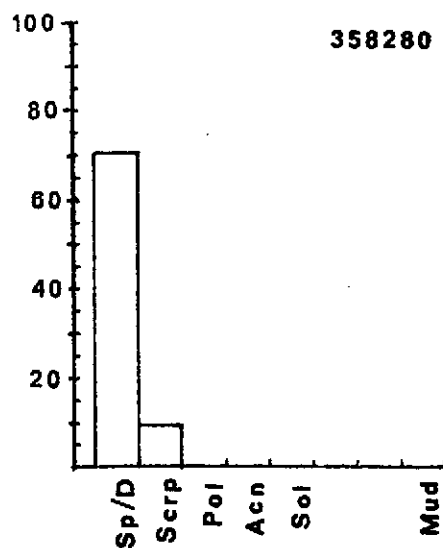FIGURE 39
Percent Cover: Typha Plots
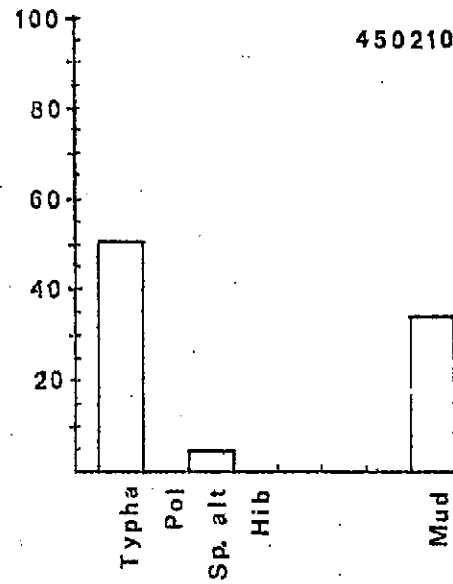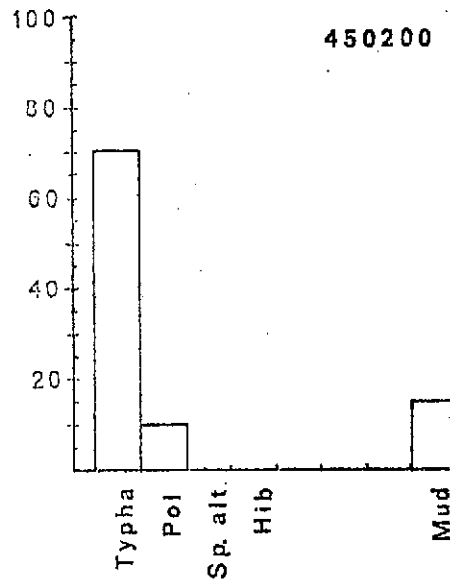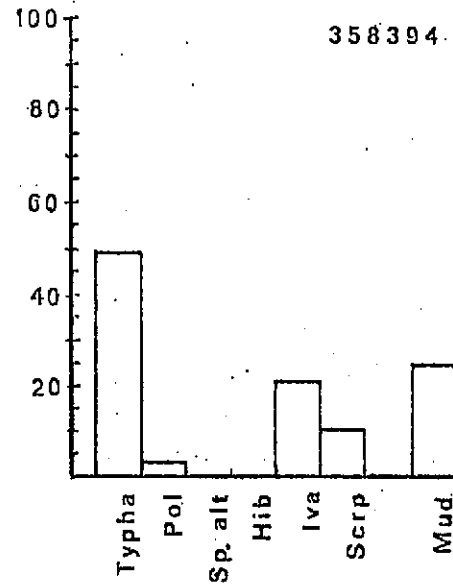
FIGURE 40

Percent Cover: Spartina patens Plots
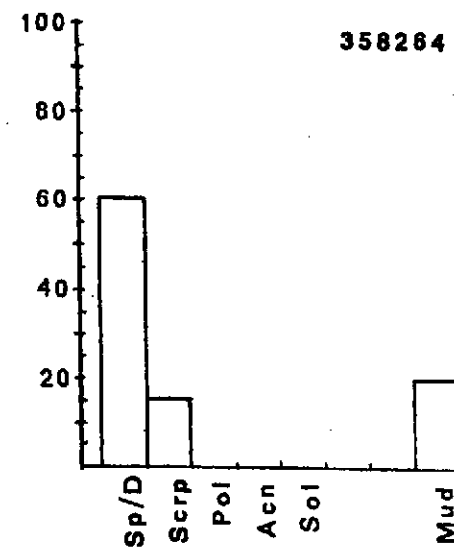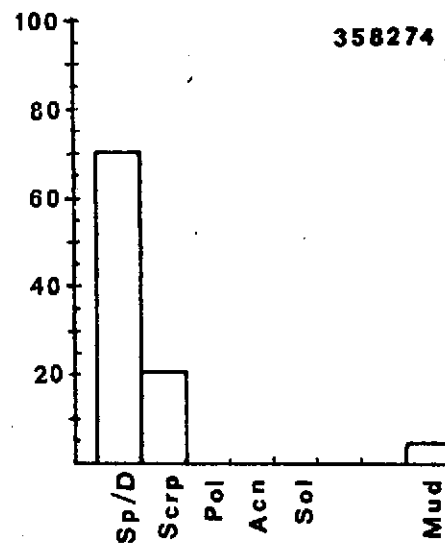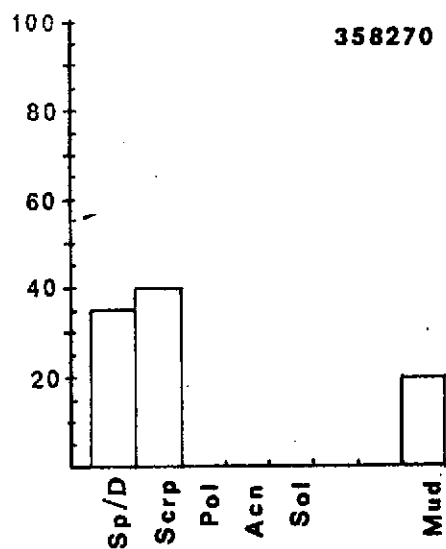
FIGURE 41

Percent Cover: Spartina patens Plots
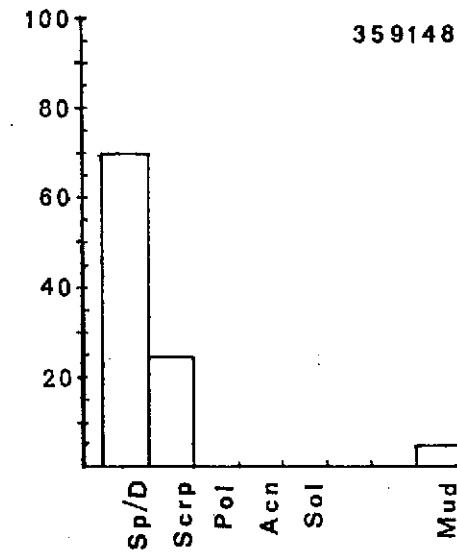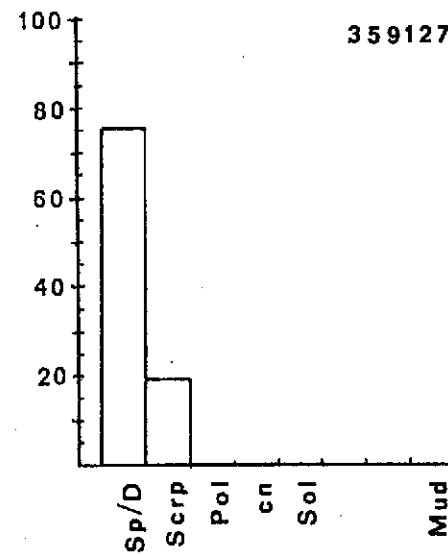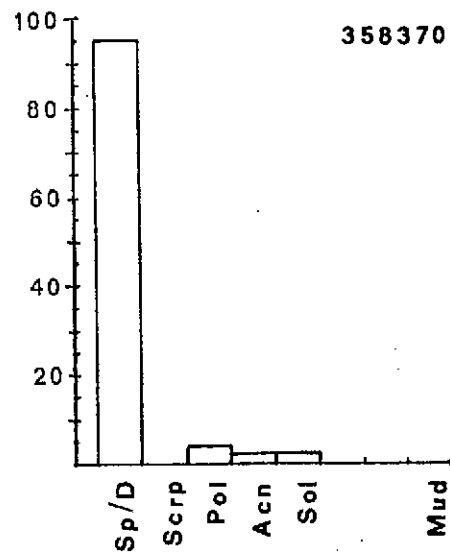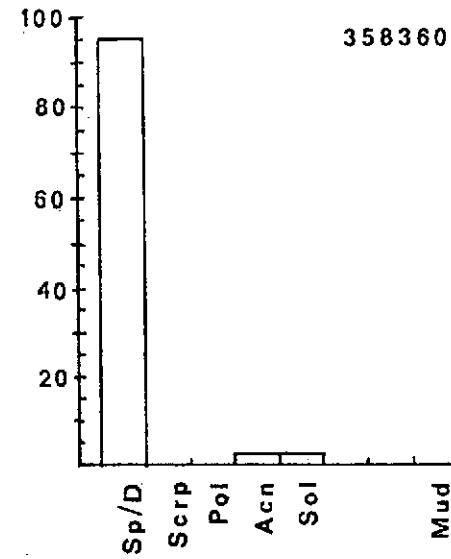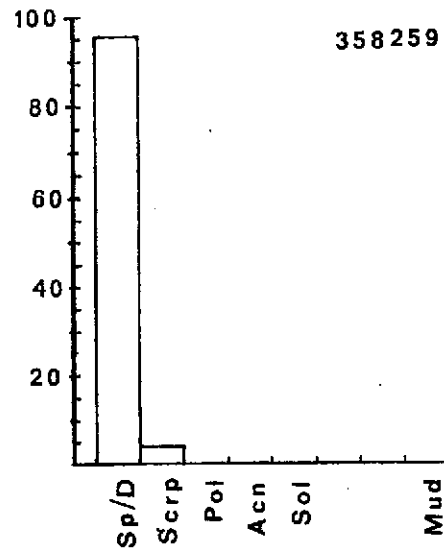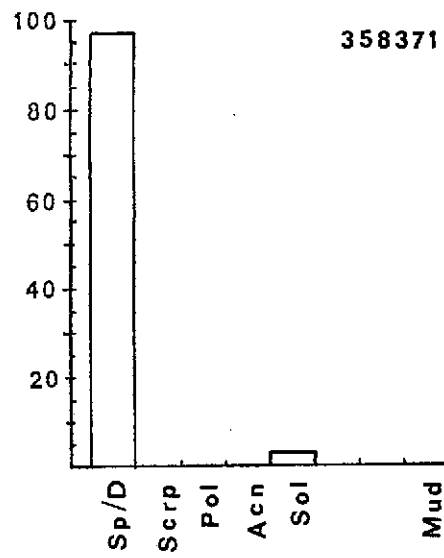
FIGURE 42

Percent Cover: Spartina patens Plots

358252

358260

359210
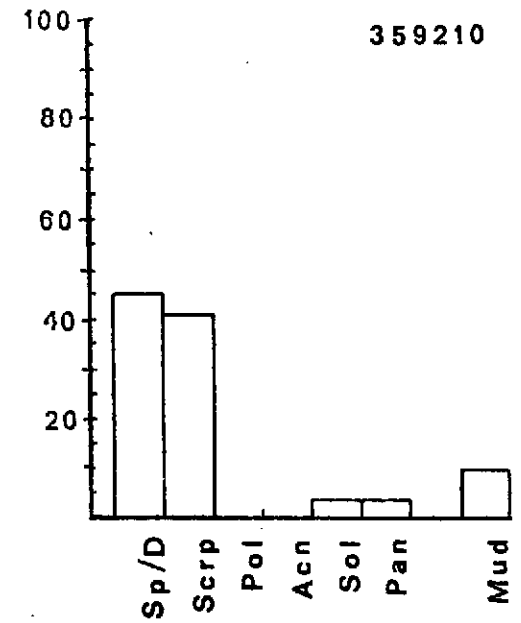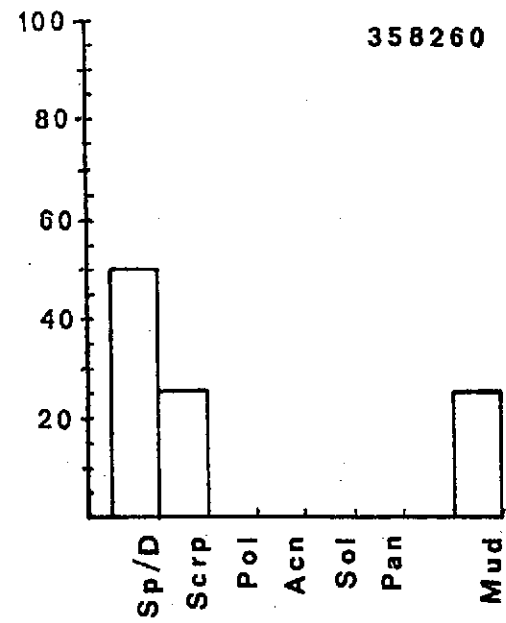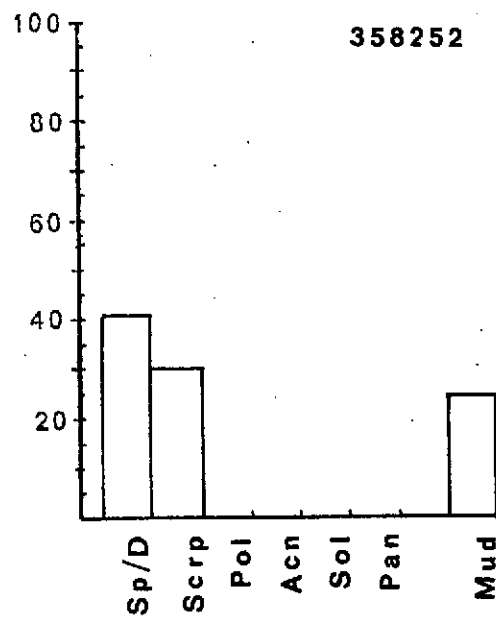
CORRELATIONS OF COVER, SPECTRAL SIGNATURE, AND PRODUCTIVITY
IN HOG ISLAND MARSH

Successful correlations between marsh productivity and color infrared aerial photos have been made by Reimold (1971) and the results used for land management decisions. Reimold worked with a very large marsh of basically one community type: Spartina alterniflora. He found that the brighter and more saturated red colors on color infrared aerial transparencies were associated with more productive Spartina alterniflora areas in the marsh.

Since the marshes of Rhode River are small and heterogeneous, an attempt was made to use Reimold's method as an indicator of productivity differences between, rather than within plant communities. In Table 4, standing crop measurements taken in July and August 1971, for eight communities in Hog Island Marsh are compared with the color of these communities in Hog Island an Kirkpatrick Marshes and with the percent cover of the type species. The aerial transparencies used for this comparison were taken August 24, 1971 from an altitude of 3500 feet.

The correlation between standing crop and color saturation is ambiguous because of the characteristics of the different communities examined. In August, Typha angustifolia has dark brown flowering heads, Panicum virgatum has purplish brown flowering heads, and Phragmites communis has very dense, tan or purplish flowering heads. These flowering heads appear brown or brown-green on color infrared photos and consequently obscure bright green (red on color infrared) foliage underneath. There is understandably little correlation between cover and standing crop since small plants such as Spartina patens may form a dense cover while tall plants such as Typha angustifolia, with greater biomass per unit area, may form a sparse cover.

70

TABLE 4

Community	Standing Crop (g dry wt/m^2) [1].	Color on Color Hog Island Marsh	IR Photos Kirkpatrick Marsh	Mean Cover (% 2-m^2 plot)
Phragmites communis	1114 ± 990	bright pink	bright red	
Spartina cynosuroides	672 ± 300	brown/red	bright red	
Typha angustifolia	626 ± 163	brown/red	brown/red	56
Spartina alterniflora	587 ± 158	bright/dull red	bright/dull	
Iva frutescens	534 ± 177	dull red	dull red	25
Scirpus Olneyi	472 + 139	tan red	tan red	
Spartina patens/ Distichlis spicata	445 ± 125	light pink	light pink	70
Panicum virgatum	369 ± 104	dull red/ brown	dull red	

1. From Drake and Hayes, unpublished data.

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Krumpe, P.F., H.R. DeSelm, and C.C. Amundsen. 1971. The delineation of forest cover and site parameters by multiband remote sensing. American Society of Photogrammetry, 37th annual meeting, March, 1971. Pp. 98-122.

Reimold, R.J. 1971. Remote sensing of salt marsh productivity. Proc. Third Biennial Workshop on Color Aerial Photography in Plant Sciences. March 2-4, 1971. Gainesville, Fla. American Society of Photogrammetry. 13 pp.